

3.0 Ecological Restoration Master Plan

The Ruddiman Creek and Nearby Shoreline Ecological Restoration Master Plan is intended to guide future restoration efforts in the project area, in accordance with the vision and guiding principles outlined below. Key elements of the Master Plan include the restoration of natural landscapes to attain self-sustaining, reproducing, native populations of species and assemblages, ecosystem resiliency, biodiversity, and the mitigation of threats to these ecosystems. Restoration will be done in accordance with the goals of the Muskegon Lake Remedial Action Plan (RAP). Reference ecosystems are used to determine species assemblages and desired ecosystem function. The restoration strategies will integrate reference system data to enhance existing ecological communities, in accordance with the range of human uses in the project area. Finally, the Ecological Restoration Master Plan will leverage and enhance recreational, educational, and stewardship opportunities that are compatible with these ecological principles.

It is acknowledged that the full restoration of ecosystem function for natural areas along Ruddiman Creek and the Muskegon Lake shoreline is a process that will take many years or decades to evolve. The natural succession of restored areas will allow habitat to mature and diversify over time. Many of the restoration actions proposed in this Master Plan will take many years to become fully developed. Further, they will require active monitoring and adaptive management to ensure that habitat complexes and desired species assemblages remain intact.

To provide an adequate planning framework, it is intended that this document serve as a “living plan” that will guide these long-term restoration and management actions. In addition, the Master Plan is structured to be adaptive to new information, stakeholder needs, and management objectives.

The vision and guiding principles, as well as specific restoration opportunities and constraints were identified at the first public workshop. The Biohabitats team translated and developed these ideas into a hierarchy of Goals, Objectives, and Actions, adding details and articulating specific strategies according to their professional expertise in ecological restoration. The Goals are broad statements about what should be accomplished in the area. Each Objective includes a measurable trajectory. Individual Actions include a procedure for implementation, reference ecosystems, planning level cost estimates for the design, implementation, and management of each action, a timeline of the restoration process, notes on any permitting requirements, and any pre-implementation requirements. The Objectives and Actions presented in this document should be further developed during the Plan execution and the ongoing monitoring process.

The final prioritization of objectives and actions was completed at the second Public Workshop held on November 29th, 2007. During the workshop, stakeholders were encouraged to provide direct input on the restoration framework described in the following sections.



Ecological Restoration Master Plan

3.1 Restoration Goals / Objectives / Actions

Goal A: Improve hydrology and water quality and in Ruddiman Creek

Objective A1) Reduce flashy flows within Ruddiman Creek.

- Action 1.** Review existing hydrologic analysis and determine data gaps and needs for additional research.
- Action 2.** Identify properties and areas in the watershed where stormwater Best Management Practices (BMPs) would be practical and beneficial, including retrofits of existing outfalls, where feasible.
- Action 3.** Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.
- Action 4.** Educate landowners about stormwater BMPs to reduce overland flow of stormwater.

Objective A2) Improve water quality of Ruddiman Creek.

- Action 1.** Continually monitor, identify and eliminate illicit discharges.
- Action 2.** Install BMPs that facilitate water quality treatment, and where feasible, infiltration.
- Action 3.** Educate homeowners about water quality BMPs

Goal B: Restore fish and wildlife habitat within the project area.

Objective B1) Enhance physical aquatic habitat features in the project area.

- Action 1.** Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.
- Action 2.** Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.
- Action 3.** Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.
- Action 4.** Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.

Objective B2) Protect and enhance native aquatic vegetation along the Muskegon Lake shoreline.

- Action 1.** Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots, for species expansion.

Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.

- Action 1.** Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Boulevard.
- Action 2.** Expand the riparian and upland buffers along the Muskegon Lake shoreline, and along the bike path.
- Action 3.** Reconfigure the Glenside Boulevard culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.

Objective B4) Restore and enhance existing wetlands throughout the project area.

- Action 1.** Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.
- Action 2.** Explore opportunities for wetland creation at the former AMOCO tank farm site.
- Action 3.** Encourage private landowners to establish native wetland vegetation where it is compatible with current zoning, future development plans, and where proper hydrology and soils exist.

Objective B5) Reduce the abundance of invasive plant species in the project area.

- Action 1.** Conduct invasive species management in project area.
- Action 2.** Provide information to homeowners about invasive species management and the use of native plants in the landscape.



Goal C: Restore fish and wildlife populations in the project area.

Objective C1)	Track the abundance and diversity of avian, fish, herpetofauna and macroinvertebrate species in the project area. Action 1. Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities within the project area
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Goal D: Permanently protect and conserve existing and restored habitats.

Objective D1)	Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat. Action 1. Work with the City of Muskegon to consider stronger protection of 50 acres designated as open space recreation, including the former AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon. Action 2. Propose and enact conservation zoning for 7 acres of shoreline between the former AMOCO Tank Farm Site, and Lakeshore Yacht Club.
Objective D2)	Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat. Action 1. Initiate discussions with private landowners to determine the types of conservation measures that could increase property value and enhance future development plans. Action 2. Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.

Goal E: Increase opportunities for recreation, education, and stewardship.

Objective E1)	Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing. Action 1. Explore the feasibility of placing an observation platform within the lagoon.
Objective E2)	Encourage opportunities for active recreation along, and in Ruddiman Creek and the Nearby Shoreline of Muskegon Lake. Action 1. Explore the feasibility of placing a boardwalk in the lagoon area. Action 2. Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.
Objective E3)	Promote local stewardship and education opportunities. Action 1. Elicit support from adjacent schools to have students implement and monitor restoration measures. Action 2. Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures. Action 3. Maintain and promote research opportunities through Grand Valley State University (GVSU). Action 4. Hold seasonally relevant seminars on the ecology, history, environmental stewardship, or function of the area. Action 5. Encourage construction of informational signage describing local history vegetation and wildlife.

Goal A)

Improve hydrology and water quality in Ruddiman Creek

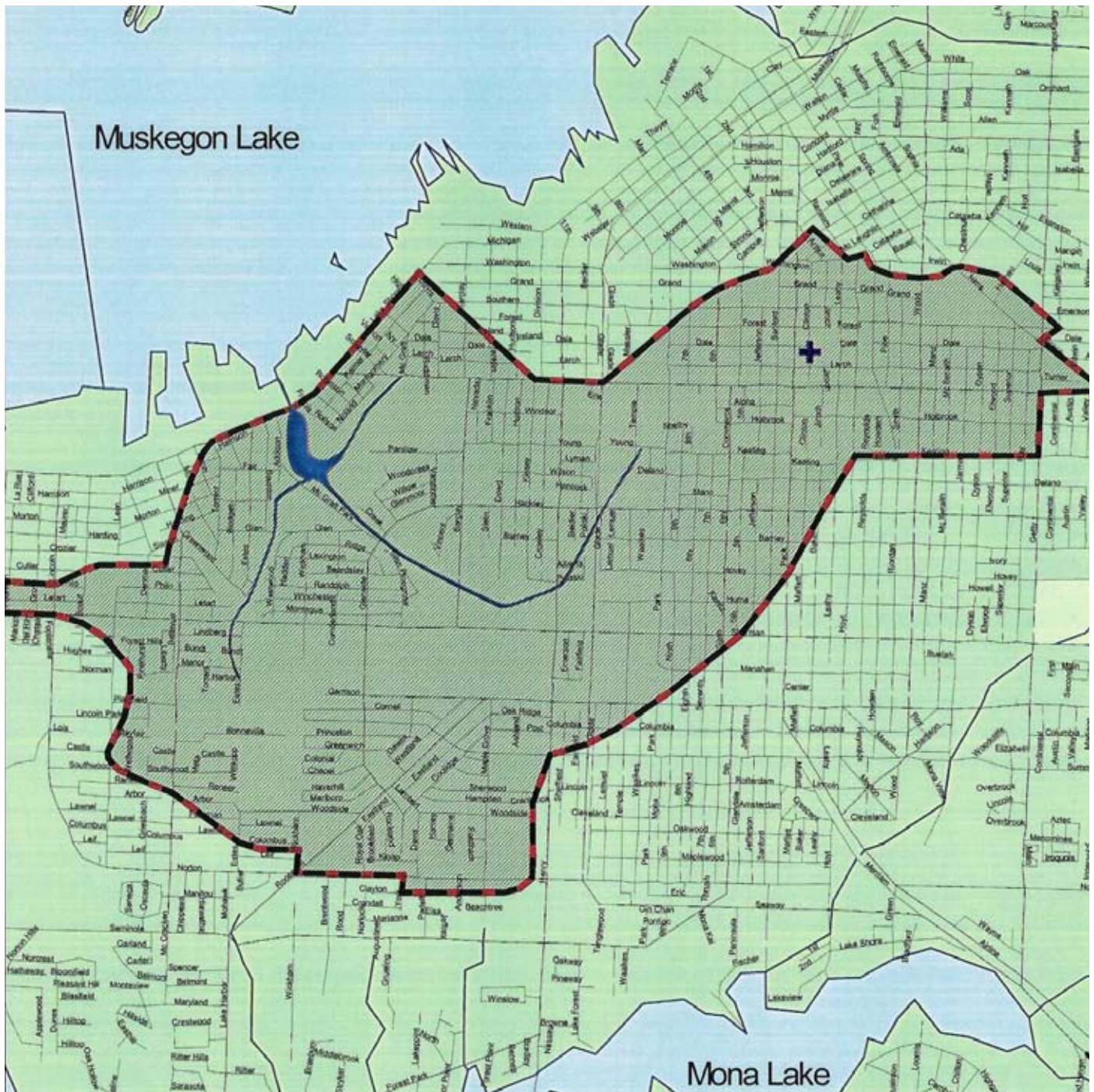
Overview

Sediment remediation efforts have successfully removed contaminated sediments from within the Ruddiman Creek channel and subsurface areas of the lagoon to levels that comply with federal and state standards. However, Ruddiman Creek is still subject to the impacts from an urbanized watershed, including pollutants, bacteria, flashy hydrology and reduced infiltration.

To ensure the health of a restored aquatic system, and provide for sustained use by plant, invertebrate, fish, bird, wildlife, and human inhabitants, it is necessary to maintain water conditions so that they do not limit ecological function and biodiversity, or be continual sources of ecological stress.

Objectives

- A1)** Reduce flashy flows within Ruddiman Creek
- A2)** Improve water quality of Ruddiman Creek



0 800 1600 2400 3200 4000 4800 Feet

LEGEND

— Watershed Boundary



Ruddiman Creek Watershed

Phase II Drift Sampling
and Analysis Plan
Ruddiman Creek / Muskegon, Michigan
Revision 00 / May 2000

Ecological Restoration Master Plan

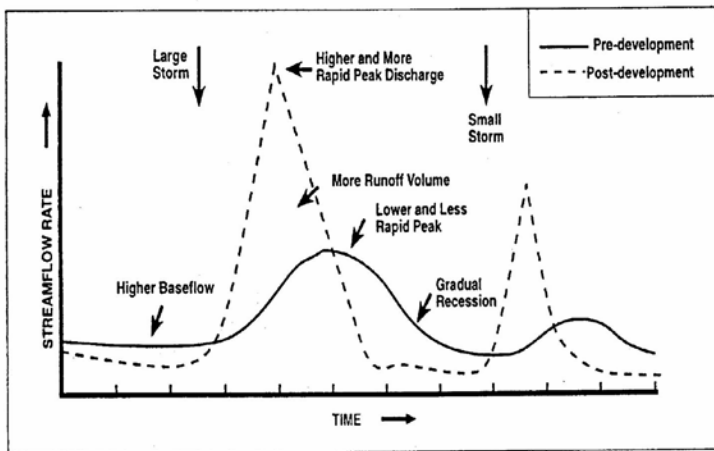
Goal A) Improve hydrology and water quality in Ruddiman Creek

Objective A1) Reduce flashy flows within Ruddiman Creek

***Restoration Trajectory:** Restore the discharge of Ruddiman Creek to resemble the annual discharge regime observed in a less urbanized watershed.*

Overview

Approximately two thirds of the Ruddiman Creek watershed has been culverted and/or placed in storm sewers. When rain water hits the parking lots streets and driveways in the



watershed, it is rapidly transported to the storm sewers, which quickly deliver it to the stream channel. Rain water has little opportunity to infiltrate into the ground, and instead, enters the stream channel with erosive velocities and flooding volumes. The Cities of Muskegon, Norton Shores, Muskegon Heights and Roosevelt Park are undertaking programs to address pollution and impacts associated with stormwater runoff (see Section 5.4). Additional efforts that should be considered are described below.

Above, typical stormwater hydrograph; opposite page, stormflows increased from impervious surfaces in the watershed

Actions

- 1) Review existing hydrologic analysis and determine data gaps and needs for additional research.
- 2) Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.
- 3) Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.
- 4) Educate landowners about stormwater BMPs to reduce overland flow of stormwater.



Ecological Restoration Master Plan

Goal A) Improve hydrology and water quality in Ruddiman Creek

Objective A1) Reduce flashy flows within Ruddiman Creek

Action A1:1

Review existing hydrologic analysis and determine data gaps and needs for additional research.

Procedure

- A)** Review and, if necessary, build upon the existing HEC-HMS model (computer model used to estimate the relationship between rainfall and run-off) for Ruddiman Creek to analyze the existing hydrologic regime and to identify problem areas within the watershed. Problem areas may include those impacted by overbank flows or flooding during storms of different return intervals.
- B)** Identify flow-related targets for the watershed based on this analysis. These may include a variety of objectives, such as reduced flooding at road crossings during the 10-year storm event, increased summer baseflows to enhance habitat, reduced overbank or nuisance flooding during small storms, etc.
- C)** Coordinate with local municipalities and state agencies to implement actions that facilitate and support current efforts.



Field reconnaissance to verify existing data

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide

Implementation Timeline: 0 to 2 years



Years from Master Plan adoption

Range of estimated costs: \$25,000 - \$40,000

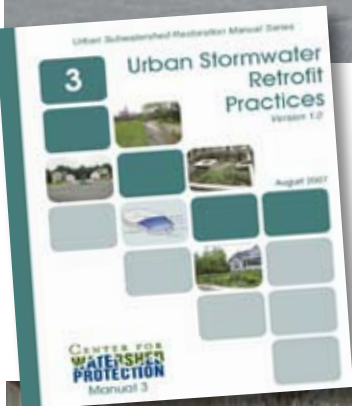
Permitting requirements: None

Pre-implementation needs: GIS layers including soils, land use and watershed topography, and existing storm drain network.



Goal A) Improve hydrology and water quality in Ruddiman Creek
Objective A1) Reduce flashy flows within Ruddiman Creek

Action A1:2) Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.



Above, identifying potential BMP; at left, stormwater report cover; below, potential BMP



Procedure

- A)** Perform a GIS analysis of publicly held properties that would make potential candidates for the installation of stormwater retrofits and BMPs.
- B)** Conduct a windshield survey to verify the desktop analysis and identify additional potential BMP sites.
- C)** Use the information above and the hydrologic information from Action 1 to create a watershed-specific stormwater management plan including feasibility and priority analysis of proposed BMP sites, and policies for new development and infill development. This stormwater management plan should both draw from and support relevant actions undertaken by the cities as part of their Stormwater Pollution Prevention Initiatives.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 0 to 2 years



Years from Master Plan adoption

Range of estimated costs: \$20,000 - \$70,000

Permitting requirements: None

Pre-implementation needs: GIS layers including soils, land use and geo-referenced aerial photography.

Ecological Restoration Master Plan

Goal A) Improve hydrology and water quality in Ruddiman Creek

Objective A1) Reduce flashy flows within Ruddiman Creek

Action A1:3)

Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.

Procedure

- A) Create concepts and final construction plans for the prioritized BMPs from the Stormwater Master Plan.
- B) Bid and construct the selected BMPs.
- C) Monitor and maintain BMPs.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

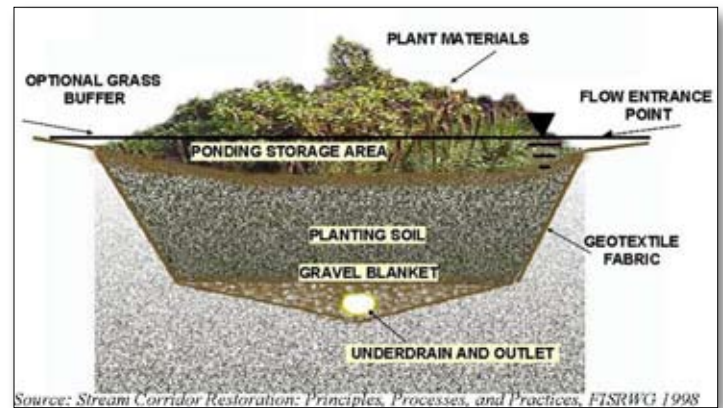
Implementation Timeline: 3 - 10-years



Range of estimated costs: \$700,000 - \$2,100,000
(for full implementation of the Plan).

Permitting requirements: Local, state and federal permits will be required for work in and around waterways, and for any development, redevelopment, or retrofit stormwater credit to be received.

Pre-implementation needs: Results of Actions 1 and 2 above.



BMP diagram

Goal A) Improve hydrology and water quality in Ruddiman Creek
Objective A1) Reduce flashy flows within Ruddiman Creek

Action A1:4) Educate landowners about stormwater BMPs to reduce overland flow of stormwater.



At top, BMP example; above, parking lot bioretention

Procedure

- A)** Coordinate with existing programs designed for landowners, add a stormwater BMP (rain gardens, rain barrels, porous pavement, etc.) component and increase educational opportunities in the Ruddiman Creek Watershed.
- B)** Provide workshops, forums, networks and incentives associated with community organizations.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 3 to 10 years



Range of estimated costs: \$1,000 - \$2,000 (efforts to be repeated annually).

Permitting requirements: N/A

Pre-implementation needs: N/A

Ecological Restoration Master Plan

Goal A) Improve hydrology and water quality in Ruddiman Creek

Objective A2) Improve water quality of Ruddiman Creek.



Restoration Trajectory: *Ensure that Ruddiman Creek does not receive untreated water from illicit discharges, cross connections, or stormwater drainage features.*



Overview

Runoff from parking lots and roadways carries chemical byproducts of petroleum combustion, nutrients, road grit, bacteria from pet waste and sewer mammals, and other pollutants into the stream channel, reducing water quality. Conversely, during dry weather there is little groundwater discharge to the channel. This results in extremely low flows in the channel that concentrate the deposited pollutants and stress aquatic fauna. Other contamination of the creek occurs from leaks and cross connections to the sanitary sewer system into the storm sewers.

Actions

- 1) Continually monitor, identify and eliminate illicit discharges.
- 2) Install BMPs that facilitate water quality treatment, and where feasible, infiltration.
- 3) Educate homeowners about water quality BMPs



At top and bottom, examples of outfalls; center, sign warning of pollution at Ruddiman Creek

Goal A) Improve hydrology and water quality in Ruddiman Creek
Objective A2) Improve water quality of Ruddiman Creek

Action A2:1) Continually monitor, identify and eliminate illicit discharges.



Examples of discharges



Procedure

- A)** Ensure that existing illicit discharge elimination programs administered by the Cities of Muskegon, Norton Shores, Muskegon Heights and Roosevelt Park monitor all potential sources of illicit discharges to Ruddiman Creek.
- B)** Identify illicit connections and discharges, and report them to the governing agencies for corrective action.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide
(approximately 2,994 acres)

Implementation Timeline: Continuous



Range of estimated costs: \$5,000 - \$10,000
(annually)

Permitting requirements: None

Pre-implementation needs: None

Ecological Restoration Master Plan

Goal A) Improve hydrology and water quality in Ruddiman Creek

Objective A2) Improve water quality of Ruddiman Creek

Action A2:2) Install BMPs that facilitate water quality treatment, and where feasible, infiltration.

Procedure

- A) Concurrent with Objective A1 above, identify locations for BMPs that focus on water quality benefits as well as quantity control.
- B) Educate private and commercial property owners about BMPs that can be installed on site.
- C) Develop a ranking system to prioritize BMPs for implementation. This ranking system should take into account both technical information and public concerns.
- D) Design, bid and construct BMPs
- E) Monitor and maintain BMPs



Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 3 to 10 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: See Objective A1, Action 3, above

Permitting requirements: Likely that local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: See Objective A1 above.



Examples of BMPs

Goal A) Improve hydrology and water quality in Ruddiman Creek
Objective A2) Improve water quality of Ruddiman Creek

Action A2:3) Educate homeowners about water quality BMPs.



At top and right, examples of residential BMP action; above signs encouraging individual action.



Procedure

- A)** Coordinate with existing programs designed for landowners, add a water quality BMPs (fertilizer application, low phosphorus soaps, car washing, pet waste, etc.) component and increase educational opportunities in the Ruddiman Creek Watershed.
- B)** Provide consistent and frequent reminders of what homeowners can do to improve water quality.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 3 to 10 years



Range of estimated costs: \$500 - \$1,000.

Permitting requirements: N/A

Pre-implementation needs: N/A

Ecological Restoration Master Plan

Goals, objectives and actions where hydrolaulic analyses are useful and/or necessary

H&H Needs

Goal	Objective	Action	BUI
Goal A: Improve hydrology and water quality in Ruddiman Creek.	Objective A1) Reduce flashy flows within Ruddiman Creek.	Action A1.1 - Review existing hydrologic analysis and determine data gaps and needs for additional research.	✓
		Action A1.2 - Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.	✓
		Action A1.3 - Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1.2 above.	✓
		Action A1.4 - Educate landowners about stormwater BMPs to reduce overland flow of stormwater.	
Goal B: Restore fish and wildlife habitat within the project area.	Objective A2) Improve water quality of Ruddiman Creek.	Action A2.1 - Continually monitor, identify and eliminate illicit discharges.	
		Action A2.2 - Install BMPs that facilitate water quality treatment and where feasible, infiltration.	✓
	Objective B1) Enhance physical aquatic habitat features in the project area.	Action A2.3 - Educate homeowners about water quality BMPs.	✓
		Action B1.1 - Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.	✓
	Objective B2) Protect and enhance native submerged aquatic vegetation along the Muskegon Lake shoreline.	Action B1.2 - Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.	✓
		Action B1.3 - Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.	✓
	Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.	Action B1.4 - Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.	✓
		Action B2.1 - Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.	✓
	Objective B4) Restore and enhance existing wetlands throughout the project area.	Action B3.1 - Expand the Ruddiman Creek riparian buffer within McGrath Park between Lakeshore Drive and Glenside Blvd.	
		Action B3.2 - Expand the riparian and upland buffers along the Muskegon Lake shoreline, and along the bike path.	
Goal C: Restore fish and wildlife populations in the project area.	Objective B5) Reduce the abundance of invasive plant species in the project area.	Action B3.3 - Reconfigure the Glenside Avenue culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.	✓
		Action B4.1 - Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.	✓
	Objective C1) Track the abundance and diversity of native avian, fish, herpetofauna, and macroinvertebrate species in the project area.	Action B4.2 - Explore opportunities for wetland creation at the former AMOCO tank farm site.	
		Action B4.3 - Encourage private landowners to establish native wetland vegetation where it is compatible with future development plan and where proper hydrology and soils exist.	
	Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.	Action B5.1 - Conduct invasive species management in the project area.	
		Action B5.2 - Provide information to homeowners about invasive species management and the use of native plants in the landscape.	
	Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.	Action C1.1 - Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities in the project area.	
		Action D1.1 - Work with the City of Muskegon to consider stronger protection of 50 acres designated as open space recreation, including the former AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.	
	Objective E1) Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing.	Action D1.2 - Propose and enact conservation zoning for 7 acres of shoreline between the former AMOCO Tank Farm Site, and Lakeshore Yacht Club.	
		Action D2.1 - Initiate discussions with private land owners to determine the types of conservation measures that could increase property value and enhance future development plans.	
Goal E: Increase opportunities for recreation, education, and stewardship.	Objective E2) Encourage opportunities for active recreation along, and in Ruddiman Creek and the nearby shoreline of Muskegon Lake.	Action D2.2 - Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.	
		Action E1.1 - Explore the feasibility of placing an observation platform within the lagoon.	✓
	Objective E3) Promote local stewardship and education opportunities.	Action E2.1 - Explore the feasibility of placing a boardwalk in the lagoon area.	✓
		Action E2.2 - Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.	
		Action E3.1 - Elicit support from adjacent schools to have students implement and monitor restoration measures.	
		Action E3.2 - Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.	
		Action E3.3 - Maintain and promote research opportunities through GVSU.	
		Action E3.4 - Hold seasonally relevant seminars on the ecology, history, environmental stewardship and function of the area.	
		Action E3.5 - Encourage construction of informational signage describing local history vegetation and wildlife.	

Goal B)

Restore fish and wildlife habitat within the project area.

Overview

As presented in the Existing Conditions section of this plan, the Muskegon Lake shoreline, Ruddiman Lagoon, and Ruddiman Creek contain a variety of habitat complexes which support, or can support a high degree of biodiversity. Many locations in the project area are not in need of wholesale, ecological restoration actions and may only require minor enhancement to improve habitat conditions.

The Ruddiman Creek corridor contains a range of habitats that are in a state of active succession as vegetation communities and soils recover from the past remediation. Here, focused restoration strategies have been proposed to enhance specific habitat elements (e.g. woody debris enhancement) that will improve ecosystem function. Full restoration is proposed in the more degraded habitats including, the former AMOCO Tank Farm, and the hardened shoreline areas and lacustrine wetlands along Muskegon Lake. These locations contain degraded habitats, or present excellent opportunities for expanding existing natural areas, and re-establishing native species diversity and natural communities.







Objectives

- B1)** Enhance physical aquatic habitat features within the project area.
- B2)** Protect and enhance native aquatic vegetation along the Muskegon Lake Shoreline.
- B3)** Enhance terrestrial habitat including riparian buffers and corridors in the project area.
- B4)** Restore and enhance existing wetlands throughout the project area.
- B5)** Reduce the abundance of invasive plant species in the project area.



Habitat Enhancements that Target Fish and Benthic Communities

Legend

- | | | |
|--|--|---|
|  Project Area |  Woody Debris Enhancement |  Remove Debris and Install Grade Control |
|  Aquatic Vegetation |  Reconfigure Culvert |  Shoreline Reconfig |

0 500 1,000 2,000 3,000 4,000 Feet



Objective B1) Enhance physical aquatic habitat features in the project area.

Restoration Trajectory: Provide suitable aquatic habitats including woody debris and naturally sloped, vegetated shorelines to support diverse aquatic wildlife.

Overview

The general aquatic habitat types that exist in the project area include the Muskegon lakeshore and littoral zone, the shallow open water marsh of the Ruddiman lagoon, and the headwater stream habitats found in Ruddiman Creek. As described in the Existing Conditions section of this plan, each of these areas have suffered from human impacts and will require some habitat enhancement to again support diverse aquatic fauna.

Actions

- 1) Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.
- 2) Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.
- 3) Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.



Concrete Rubble near the mouth of Ruddiman Creek.

Ecological Restoration Master Plan

Goal B) Restore fish and wildlife habitat within the project area.

Objective B1) Enhance physical aquatic habitat features in the project area.

Action B1:1) Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.

Procedure

- A) Explore the feasibility of concrete removal and shoreline recontouring, including permitting, and potential contaminant release.
- B) Develop concepts, and construction documents for each area of impacted shoreline that account for wave energy, and ice scour.
- C) Bid and construct these projects.

Implementation details

Reference conditions: The Duck Lake and Pentwater Lake shorelines provide good reference for slope and vegetation. Additional engineering measures may be required to maintain stability along the Muskegon Lake shoreline.

Affected area/size: Roughly 4,000LF of concrete shoreline exist in the project area.

Implementation Timeline: 2 to 10 years



Range of estimated costs: \$420,000 - \$1,200,000
(Planning level costs assume no contamination in the fill and no additional remediation requirement.)

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Assessment of the lateral extents of concrete fill and analysis of the potential release of contaminants will be required.



Examples of concrete fill and woody debris at Muskegon Lake

- Goal B)** Restore fish and wildlife habitat within the project area.
- Objective B1)** Enhance physical aquatic habitat features in the project area.

Action B1:2) Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.



At top, existing debris; above and left, examples of grade control

Procedure

- A)** Explore the feasibility of debris removal at the Ruddiman mouth, including permitting, and potential contaminant release.
- B)** Perform engineering studies to determine the appropriate water level to be maintained in the lagoon while considering public opinion and wildlife passage.
- C)** Develop concepts, and construction documents for a more natural step, cascade, riffle or vane structure that will improve fish passage into Ruddiman lagoon.

Implementation details

Reference conditions: N/A

Affected area/size: 2,500 square feet

Implementation Timeline: 0 to 2 years



Range of estimated costs: \$10,000 - \$40,000
(Planning level costs assume no contamination in the fill and no additional remediation requirement.)

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Assessment of the extents of debris and the potential release of contaminants will be required.

Ecological Restoration Master Plan

Goal B) Restore fish and wildlife habitat within the project area.

Objective B1) Enhance physical aquatic habitat features in the project area.

Action B1:3) Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.

Procedure

- A)** Survey the frequency of woody debris along the forested sections of Ryerson Creek and relatively unimpacted reaches of similar size in the Muskegon River watershed.
- B)** Identify potential locations for placement of woody debris and perform analytical tests of the soils and sediment in these locations.
- C)** Locate and incorporate woody debris for habitat variability within the remediated areas of the Ruddiman channel, and in the Ruddiman lagoon downstream from Glenside Boulevard.



Examples of large woody debris used for wetland (above) and stream (left) habitat

Implementation details

Reference conditions: Ryerson Creek and tributaries to the Muskegon River

Affected area/size: Ruddiman Corridor

Implementation Timeline: 0 to 2 years



Range of estimated costs: \$10,000 - \$20,000-
(Planning level costs assume no contamination identified and no additional remediation requirement.)

Permitting requirements: Local, state and federal permits may be required for work in and around waterways.

Pre-implementation needs: None.

- Goal B)** Restore fish and wildlife habitat within the project area.
- Objective B1)** Enhance physical aquatic habitat features in the project area.

Action B1:4) Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.



At right, Glenside culvert; above and below, culverts created for improved fish passage



Procedure

- A)** Explore the feasibility of redesigning the culvert as a bottomless arch, and or bridge over the stream and floodplain.
- B)** Develop concepts, and construction documents for a structure that will improve fish and wildlife passage within the stream corridor.
- C)** Bid and construct this structure.

Implementation details

Reference conditions: N/A

Affected area/size: Approximately 4,000 square feet

Implementation Timeline: 20 to 50 years



Range of estimated costs: \$200,000 - \$500,000

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Hydrologic study of Ruddiman watershed per Goal A and a study of the local hydraulics at the culvert.

Ecological Restoration Master Plan

Goal B) Restore fish and wildlife habitat within the project area.

Objective B2) Protect and enhance native littoral and emergent wetland vegetation along the Muskegon Lake shoreline.



Examples of emergent wetland test plot

Restoration Trajectory: Increase the aerial coverage and diversity of littoral and emergent wetland vegetation.

Overview

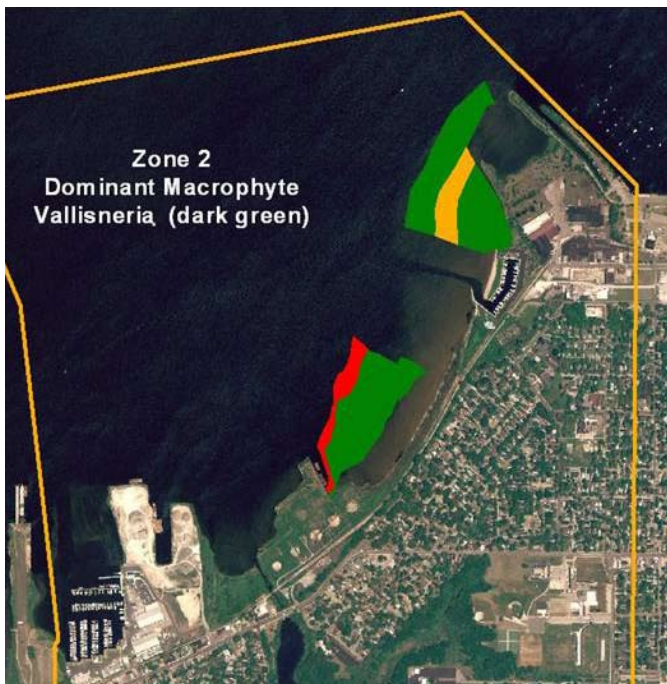
Emergent wetland provides diverse microhabitats for a wide variety of species. Their presence is necessary to support all wildlife, especially a strong fishery. Studies of the Muskegon Lake littoral zone indicate that submerged plant growth has generally decreased during the past ten years. Efforts to increase the aerial coverage and diversity of this vegetation along the lake shoreline should be initiated.

Actions

- 1) Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.

- Goal B)** Restore fish and wildlife habitat within the project area.
- Objective B2)** Protect and enhance native littoral and emergent wetland vegetation along the Muskegon Lake shoreline.

Action B2:1) Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.



Site areas for emergent wetland vegetation

Procedure

- A)** Identify areas suitable for vegetative enhancement.
- B)** Reconfigure lake sediments and shoreline areas for desired species assemblages.
- C)** Plant and monitor test plots in each location with a mix of species suitable for each location.
- D)** Broaden coverage of native aquatic vegetation through expanded plantings.

Implementation details

Reference conditions: Marsh habitats in Duck Lake and Pentwater Lake

Affected area/size: Approximately 56 acres

Implementation Timeline: 3 to 5 years



Years from Master Plan adoption

Range of estimated costs: \$60,000 - \$120,000

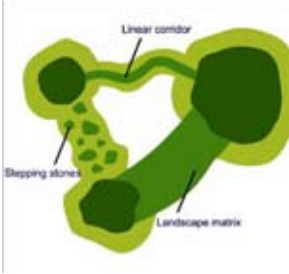
Permitting requirements: Local, state and federal permits will be required if lake sediments are reconfigured.

Pre-implementation needs: None.

Ecological Restoration Master Plan

Goal B) Restore fish and wildlife habitat within the project area.

Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.



Above, ecological corridor graphic; below, buffer width recommendations

Restoration Trajectory: *Expand all corridors in the project area to meet their full potential for water quality, flood protection, and wildlife habitat.*

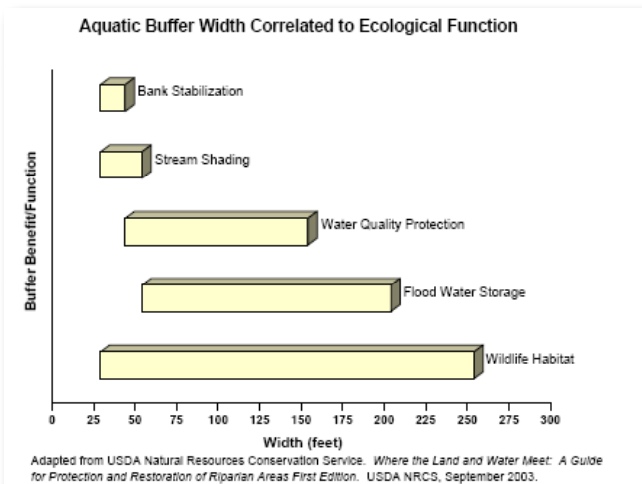
Overview

Restoring and expanding riparian buffers in the project area presents a great opportunity to expand and improve terrestrial habitat in the project area. It will also provide the potential to increase biodiversity of wildlife populations by maximizing the width and continuity of vegetative riparian corridors.

Along Ruddiman Creek, riparian buffer enhancement should concentrate on attaining an ecologically-optimal width within McGraft Park, while reducing the acreage of maintained turf grass and gravel

parking pad. A filter strip of low meadow vegetation along the lagoon shoreline would slow water flow and filter run-off entering the lagoon. It would also make the area less appealing for nuisance waterfowl like Canada geese. Native vegetation should provide cover to facilitate wildlife migration in the corridor, and human access should be controlled to minimize disturbance. While the gravel parking pad is necessary for large vehicle and overflow parking in the park, small portions of the parking lot could be reconstructed as raingardens to promote infiltration. Greater public education/opinion must also be considered before moving forward with these actions.

Along the Muskegon Lake shoreline and the bike path corridor, native forest plantings should be incorporated where the corridor and lakeside forests are dominated by invasive species, as well as where they are in an early state of succession. Opportunities for forest enhancement exist on the high slopes leading to residential properties, south of the bike path.



Actions

- 1) Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Boulevard.
- 2) Expand the riparian and upland buffers along the Muskegon Lake shoreline and along the bike path.
- 3) Reconfigure the Glenside Boulevard culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.





Ruddiman corridor
riparian buffers

Ecological Restoration Master Plan

Goal B) Restore fish and wildlife habitat within the project area.

Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.

Action B3:1

Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Boulevard.

Procedure

- A)** Conduct public opinion and education sessions to determine the need for extensive turf grass and parking along Ruddiman Creek and lagoon, and identify areas where the riparian buffer may be expanded.
- B)** Determine ecological objectives and desired buffer/corridor width.
- C)** Refer to riparian reference communities along Ryerson Creek and within the Muskegon River watershed for applicable native plant species.
- D)** Determine the appropriate recreational uses of the area and control access accordingly.
- E)** Coordinate riparian enhancement efforts with other water quality (Goal A) and habitat improvements (Goal B).

Implementation details

Reference conditions: Riparian and upland habitats along less disturbed portions of Ruddiman Creek, Ryerson Creek and within the Muskegon River watershed.

Affected area/size: Approximately 3 acres

Implementation Timeline: 1 to 5 years



Years from Master Plan adoption

Range of estimated costs: \$15,000 - \$200,000

Permitting requirements: None

Pre-implementation needs: Establish reference sites for the appropriate riparian and upland communities. Coordinate plans with the City Parks Board.



At top, turf grass buffer at Ruddiman Creek; above right, Ruddiman Corridor parking lot; above left, example of pond edge buffer

Goal B) Restore fish and wildlife habitat within the project area.
Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.

Action B3:2) Expand the riparian and upland buffers along the Muskegon Lake shoreline and along the bike path.



Above, existing lake shoreline and Bike path buffer; right, example of nice greenway buffer with bike path



USDA NRCS

Procedure

- A) Concurrent with other shoreline habitat improvements in Goal B install selected upland woodland vegetation along the Muskegon Lake shoreline and the bike path.
- B) Assess the feasibility for forest buffer enhancement on the high slopes leading to residential properties, south of the bike path.
- C) Conduct public opinion and education sessions to promote the benefits forested buffers along private properties.

Implementation details

Reference conditions: Upland habitats along the less disturbed portions of Ruddiman Creek, the Duck Lake shoreline and Pentwater Lake.

Affected area/size: 6 acres

Implementation Timeline: 1 to 5 years



Range of estimated costs: \$60,000 - \$220,000

Permitting requirements: None

Pre-implementation needs: Establish reference sites for the appropriate riparian and upland communities.

Ecological Restoration Master Plan

Goal B) Restore fish and wildlife habitat within the project area.

Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.

Action B3:3)

Reconfigure the Glenside Boulevard culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.

Procedure

- A) Explore the feasibility of redesigning the culvert as a bottomless arch, and or bridge over the stream and floodplain.
- B) Develop concepts, and construction documents for a structure that will improve fish and wildlife passage within the stream corridor.
- C) Bid and construct this structure.

Implementation details

Reference conditions: N/A

Affected area/size: Approximately 4,000 square feet

Implementation Timeline: 20 to 50 years



Years from Master Plan adoption

Range of estimated costs: \$200,000 - \$500,000

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Hydrologic study of Ruddiman watershed per Goal A and a study of the local hydraulics at the culvert.



Example of re-established pond buffer at two years

Ecological Restoration Master Plan

Goal B) Restore fish and wildlife habitat within the project area.

Objective B4) Restore and enhance existing wetlands throughout the project area.



At top, east side of Ruddiman Lagoon; above and center, examples of wetland enhancement and construction

***Restoration Trajectory:** Increase the amount and diversity of wetlands in the project area by restoring “Great Lakes Marsh” wetlands in areas covered by concrete fill and rehabilitating lacustrine wetlands along the shore of Muskegon Lake and within the former AMOCO tank farm site. Other known wetlands should be protected and/or enhanced.*

Overview

Wetlands have long been recognized as essential habitat for many species of fish and birds that utilize these areas for forage and cover, resting and breeding. In addition, wetlands provide natural “cleansing” of waters through the process of denitrification and nutrient uptake.

Historically, the Muskegon Lake shoreline and littoral zone were likely one of many Great Lakes Marsh habitats. Once the concrete debris has been removed, much of the area along the shoreline would be ideal for re-introducing this type of habitat. There are also large wetlands between the former AMOCO tank farm and the Lakeshore Yacht Club. These are largely a mosaic of common reed, and cattail. Restoring and enhancing these wetlands according to the other objectives in Goal B will greatly improve wildlife habitat and ecological function.

The feasibility of expediting the remediation of the former AMOCO tank farm site must be explored. A large wetland complex would provide the greatest habitat benefit in this area. The stakeholders and general public must determine whether it is more important to remediate this area and provide wetland enhancements, or to conduct surface remediation (capping) and focus habitat restoration efforts in other areas.

Phytoremediation offers great potential to remediate the remaining BTEX/PAH, cadmium, chromium,

PCBs and lead which may be occurring along the Muskegon Lake shoreline in the area of the former AMOCO tank farm. Phytoremediation is the process of using plants to stabilize and/or remove low-moderate level contaminants from water and soils. Phytoremediation can and also provide direct habitat benefits during the remediation process that are not possible with other methods.

This technique consists of a collection of four different mechanisms of action for the remediation of polluted soil or water.

- **Phytovolatilization:** Plants take up water and organic contaminants through the roots, transport them to the leaves, and release the contaminants as a reduced mixture of detoxified vapor into the atmosphere.
- **Phytostabilization:** Plants prevent contaminants from migrating by reducing runoff, surface erosion, and ground-water flow rates. “Hydraulic pumping” can occur when tree roots reach ground water, take up large amounts of water, control the hydraulic gradient, and prevent lateral migration of contaminants within a ground water zone.
- **Phytoaccumulation/extraction:** Plant roots can remove metals from contaminated sites and transport them to

Goal B) Restore fish and wildlife habitat within the project area.
Objective B4) Restore and enhance existing wetlands throughout the project area.

leaves and stems for harvesting and disposal or metal recovery through smelting processes.

- **Phytodegradation by plants:** Organic contaminants are absorbed inside the plant and metabolized (broken down) to non-toxic molecules by natural chemical processes within the plant. **Indirect microorganism stimulation:** Plants excrete and provide enzymes and organic substances from their roots that stimulate growth of microorganisms such as fungi and bacteria. The microorganisms in the root zone then metabolize the organic contaminants.

Phytoremediation has been used successfully for remediation in many locations and it is generally considered to be a cost-effective, environmentally friendly method of remediating low-moderate level contaminated areas. It is an alternative to more aggressive techniques such as sediment excavation. For example, the cost of cleaning up one acre of sandy loam soil at a depth of 50cm with plants is estimated at \$60,000-\$100,000 compared to \$400,000 for the conventional excavation and disposal method.

The phytoextraction of heavy metals such as Cadmium (Cd), Chromium (Cr) and Lead (Pb) is a viable option of remediating metal-laden soils. Addition of chelators such as organic acids to alter soil pH, fertilizing appropriately with NH₄, K and P, investigating mycorrhizal and microbe roles and perhaps utilizing biotechnology to increase biomass of plants and/or increase accumulation in high-biomass species are all proven methods of improving heavy metal-phytoextraction.

The phytoremediation of BTEX/PAH occurs through volatilization through the processes of evapotranspiration within the plant, hydraulic control and uptake of liquid contaminant, degradation of compounds within the plants metabolic processes, and decomposition by microbial populations feeding on plant root byproducts. Phytoremediation of BTEX/PAH contamination in shallow groundwater areas (-5 ft) are some of the most feasible phytotechnologies available.

After the former AMOCO tank farm site has been remediated, the feasibility of establishing a larger wetland complex between the Ruddiman Creek mouth and Lakeshore Yacht Club should be explored. Two emergent species of plants potentially targeted for re-establishment are American lotus (*Nelumbo lutea*) and wild rice (*Zizania palustris*); however, opportunities for establishing other native species should be explored.

Wild Rice

The historically important emergent macrophyte wild rice (*Zizania aquatica*) was a characteristic wetland plant species found in the region. Declines in this species have been due to human habitat manipulation, perturbations from carp and Canada geese, increased turbidity, contaminant impacts, and displacement by invasive non-native species such as purple loosestrife. It is a vital food source for migratory waterfowl. It is found in sheltered, shallow water (1.5-3 feet deep), low energy wetland systems with a silty substrate (Eggers and Reed, 1997).

Actions

- 1) Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.
- 2) Explore opportunities for wetland creation at the former AMOCO tank farm site.
- 3) Encourage private landowners to establish native wetland vegetation where it is compatible with current zoning, future development plans, and where proper hydrology and soils exist.

Ecological Restoration Master Plan

Goal B) Restore fish and wildlife habitat within the project area.

Objective B4) Restore and enhance existing wetlands throughout the project area.

Action B4:1) Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.

Procedure

- A) Remove concrete shoreline according to Objective B1, Action 1.
- B) Remove invasive species according to Objective B5.
- C) Plant and monitor test plots in each location with a mix of species suitable for each location.
- D) Plant native emergent littoral vegetation according to Objective B2:1, and other native wetland vegetation in existing wetland areas.



Above, Ruddiman marsh area; right, example of healthy marsh

Implementation details

Reference conditions: Marsh and wetland habitats in Duck Lake and Pentwater Lake

Affected area/size: Approximately 7 acres

Implementation Timeline: 3 to 10 years and ongoing



Range of estimated costs: \$70,000 - \$140,000

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: All pre-implementation tasks in Goal B (e.g. concrete removal and invasive species management).



Goal B) Restore fish and wildlife habitat within the project area.
Objective B4) Restore and enhance existing wetlands throughout the project area.

Action B4:2) Explore opportunities for wetland creation at the former AMOCO tank farm site



Examples of healthy wetlands

Procedure

- A)** Conduct a feasibility study to determine the most appropriate remediation measure for the site (e.g. phytoremediation, excavation and disposal, or capping).
- B)** Discuss costs and timelines with stakeholders and representatives from the City of Muskegon.
- C)** Determine the feasibility of creating a contiguous wetland complex from the mouth of Ruddiman Creek to the Lakeshore Yacht Club.

Implementation details

Reference conditions: Marsh and wetland habitats in Duck Lake and Pentwater Lake

Affected area/size: Approximately 30 acres

Implementation Timeline: 3 to 20 years



Range of estimated costs: \$2.0 - \$10.0 million

Permitting requirements: Hazardous disposal permits, local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Remediation of the former AMOCO tank farm site.



Wetland Creation and Enhancement

Legend

-  Project Area
-  Wetland Creation
-  Wetland Enhancement/Restoration



0 500 1,000 2,000 3,000 4,000 Feet



Goal B) Restore fish and wildlife habitat within the project area.
Objective B4) Restore and enhance existing wetlands throughout the project area.

Action B4:3) Encourage private landowners to establish native wetland vegetation where it is compatible with current zoning, future development plans, and where proper hydrology and soils exist.



Established wet swale at private residence

Procedure

- A) Continue dialogue with the owners of R.C. Productions and the Lakeshore Yacht Club, Michigan Steel, Coles Marina, and the Achterhoff family to encourage them to explore options for establishing and/or enhancing wetland habitat on their properties.
- B) If approved, establish and/or enhance wetland habitats according to landowner expectations.

Implementation details

Reference conditions: Marsh and wetland habitats in Duck Lake and Pentwater Lake

Affected area/size: 17 acres

Implementation Timeline: 1 to 5 years



Range of estimated costs: \$35,000 - \$75,000

Permitting requirements: Local, state and federal permits will be required for work in and around waterways.

Pre-implementation needs: Landowner buy-in.

Objective B5) Reduce the abundance of invasive plant species in the project area.

***Restoration Trajectory:** Reduce the threat from exotic invasive plant species and restore target assemblages of native plant communities in Ruddiman Creek and Nearby Shoreline.*

Overview

Invasive plant species are a major threat to the long term ecosystem sustainability across most habitats in the project area. Prior to restoration activities in the project area, it is imperative to undertake a comprehensive invasive species inventory and create an invasive species management plan that accounts for continued adaptive management of invasive species in the project area. This includes baseline assessment, monitoring, active control, passive control, and the combination of invasive species management with other projects such as wetland restoration, and reforestation.

Priority invasive species targeted for control are common reed (*Phragmites australis*), narrow-leaf cattail (*Typha angustifolia*), Japanese knotweed (*Polygonum cuspidatum*), and tartarian honeysuckle (*Lonicera tartarica*). Other infestations of purple loosestrife (*Lythrum salicaria*) and glossy buckthorn (*Rhamnus frangula*) should be monitored. Stands of common reed and narrow-leaf cattail dominate the wetlands between the former AMOCO tank farm site and Lakeshore Yacht Club, while Japanese knotweed is common in the upstream portions of Ruddiman Creek near Barclay Avenue. Tartarian honeysuckle is a common shrub in all upland areas and on the edge of the Ruddiman Creek floodplain.



Actions

- 1) Conduct invasive species management in the project area.
- 2) Provide information to homeowners about invasive species management and the use of native plants in the landscape.



Invasive Species Management

Legend

-  Key Invasive Species Management Areas
-  Project Boundary

0 500 1,000 2,000 3,000 4,000 Feet



Ecological Restoration Master Plan

Goal B) Restore fish and wildlife habitat within the project area.

ObjectiveB5) Reduce the abundance of invasive plant species in the project area.

Action B5:1) Conduct invasive species management in the project area.

Procedure

- A) Perform invasive species inventory and mapping using field surveys.
- B) Create an invasive species management plan that details the control method for each species, is compatible with the restoration goals of each area, and includes monitoring and adaptive management including maintenance treatment where necessary.
- C) Educate maintenance workers about invasive species and practices that can limit their proliferation.



Implementation details

Reference conditions: N/A

Affected area/size: Project area

Implementation Timeline: 1 to 5 years and ongoing



Range of estimated costs: \$7,000 - 10,000 for the inventory

\$10,000 for the invasive species management plan

\$1,200 - \$5,000 / acre for control

Total Cost is Approximately \$50,000

Permitting requirements: Proper applicator licenses of contractor.

Pre-implementation needs: None.

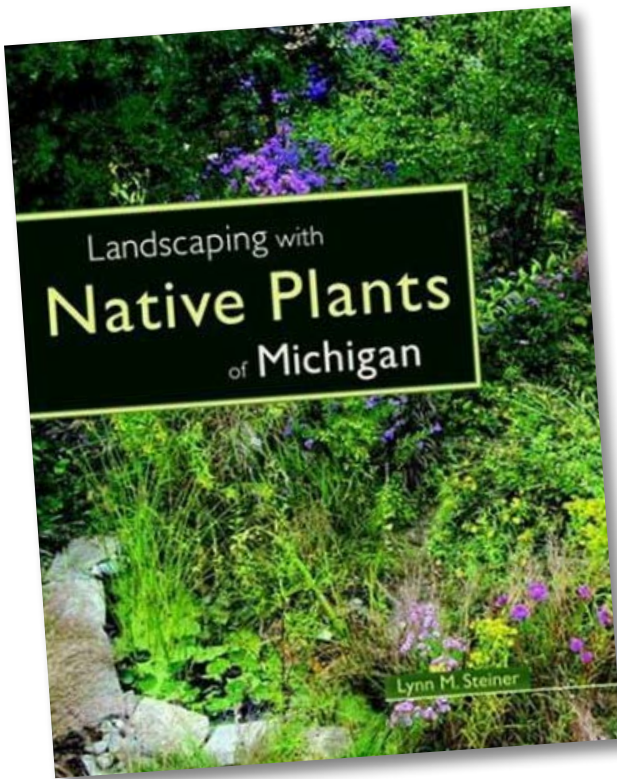


Common invasive species clockwise from top: japanese knotweed, reed canary grass and purple loosestrife



- Goal B)** Restore fish and wildlife habitat within the project area.
- ObjectiveB5)** Reduce the abundance of invasive plant species in the project area.

Action B5:2) Provide information to homeowners about invasive species management and the use of native plants in the landscape.



Publication about native plants that could be made available to homeowners for educational purposes

Procedure

- A)** Create a pamphlet about the invasive species that occur in the project area and include specific management recommendations that homeowners could implement on their property.
- B)** Host an annual native plant sale in the Ruddiman Creek watershed to promote the use of native plants.
- C)** Work with local nurseries to provide native plants and assistance for landowners.

Implementation details

Reference conditions: N/A

Affected area/size: Watershed-wide (approximately 2,994 acres)

Implementation Timeline: 3 to 10 years



Range of estimated costs: \$500 - \$1,000

Permitting requirements: N/A

Pre-implementation needs: N/A

Goal C) **Restore fish and wildlife populations according to the established vision and guiding principles.**

Overview

It is common for ecological restoration plans to include objectives associated with specific fish and/or wildlife species (e.g. rare, threatened, endangered, species of concern, etc.). In this case management actions would be implemented and monitored to track specific population goals. Conversations with local wildlife biologists and stakeholders and, review of existing data did not produce any restoration recommendations for specific populations. Therefore, a primary goal of the Plan is to restore habitat to increase biodiversity and ultimately meet the benthos, and fish and wildlife delisting targets being created by the MLWP. As a result, Goal C is directly focused on monitoring the communities targeted in Goals A and B. Rather than repeat those objectives, the objective below focuses on tracking changes in the associated communities that result from habitat improvements. The data collected from the inventories will be helpful in assessing the impacts of all of the management actions on fish and wildlife populations.

Monitoring should be incorporated into every restoration Action that is implemented, potentially including quantitative indices of vegetation, benthic macroinvertebrate, fish, amphibian and avian communities, qualitative measures of stream and wetland habitat, and monitoring for threats, such as invasive species, and chemical water quality. This information will be reported to the Master Plan managers as the Plan is implemented.

Objectives

- C 1) Track the abundance and diversity of avian, fish, herpetofauna and macroinvertebrate species in the project area.**

Actions

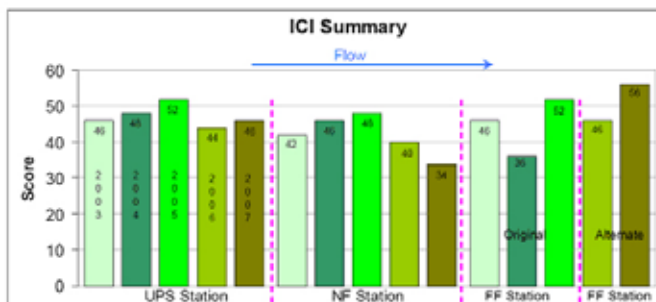
- 1) Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities within the project area**

Goal C) Restore fish and wildlife populations according to the established vision and guiding principles.

Objective C1) Track the abundance and diversity of avian, fish, herpetofauna and macroinvertebrate species in the project area.

Restoration Trajectory: Monitoring results indicate that these communities are meeting established performance criteria for the region.

Action C1:1) Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities within the project area.



At top sampling stream communities; mallard; spring peeper; and monitoring results.

Procedure

- A) Establish suitable habitats according to Goals A & B.
- B) Consult with USFWS and Michigan DNR and Michigan DEQ to identify performance standards for each community that will lead to delisting benthos, and fish and wildlife BUIs.
- C) Coordinate with groups mentioned in Goal E below to establish a monitoring program.

Implementation details

Reference conditions: Biocriteria established and agreed upon by the governing agencies and stakeholders.

Affected area/size: the project area

Implementation Timeline: 3 to 10 years with ongoing monitoring



Range of estimated costs: Based on Goals A, B, and E

Permitting requirements: Scientific collecting permit.

Pre-implementation needs: Identify leadership for a monitoring program per Goal E below.

Goal D) **Permanently protect and conserve existing and restored habitats.**

Overview

Within the Ruddiman Creek and Nearby Shoreline project area; there are many areas of open space that are either programmed as parkland, or unprogrammed and not officially used by the public. Many of these areas have a high degree of ecological value, and provide essential habitats for a diverse array of plant and animal species. The continued ecological function of these areas is dependent upon the conservation of these as open spaces to protect the natural communities from direct and indirect disturbance from conversion to urban, suburban, or industrial land uses. In addition, the longevity of areas that are programmed for restoration will be contingent upon the future conservation status of those areas.

There are five zoning categories in the project area. These are General Industrial, Open Space Conservation, Open Space Recreation, Lakefront Recreation, and Waterfront Marine. The rules and requirements of these zoning categories are included as Appendix F. This Goal proposes measures that will enable the long term protection of valuable natural areas that are currently in private ownership, or lands in public ownership that could be subject to future development actions.

Objectives









- D1)** Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.
- D2)** Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.

City of Muskegon Zoning

Legend

 Project Boundary

Zoning Code Description for Project Area

-  GENERAL INDUSTRIAL
-  LAKEFRONT RECREATION
-  OPEN SPACE RECREATION
-  OPEN SPACE CONSERVATION
-  SINGLE-FAMILY RESIDENTIAL
-  TWO-FAMILY RESIDENTIAL
-  PUD OVERLAY
-  WATERFRONT MARINE



0 400 800 1,600 2,400 3,200 Feet



Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.

***Restoration Trajectory:** Provide permanent conservation protection for publicly-owned open spaces on the east side of Ruddiman lagoon, and vacant land along the Muskegon Lake shoreline.*

Overview

Approximately 100 acres of land in the project area are owned by the City of Muskegon and zoned as open space recreation. This zoning designation provides some protection including a 75 foot setback from the ordinary high watermark of waterbodies, it may not provide adequate protection to preserve many natural features. Approximately 30 acres of this land are located on the former AMOCO tank farm site. It is an area identified in Goal B as a potentially important habitat area where a large wetland complex could be created between the Ruddiman mouth and Lakeshore Yacht Club. In addition, there is approximately 20 acres of intact upland forest designated as Open Space Recreation on the east side of the Ruddiman lagoon. Measures to re-designate these areas as more restrictive, Open Space Conservation should be explored in the future.

An additional 7 acres of land along the Muskegon Lake shoreline between the tank farm site, and Lakeshore Yacht Club are not zoned. As further described in section 5.3, this land exists as an emergent wetland that is choked with invasive plant species. It may become completely inundated during cyclical water level fluctuations in Lake Michigan and Muskegon Lake, but has been more exposed in the past few years due to lower lake water levels. If lake water levels continue to decrease, as predicted by global climate models, it is foreseeable that, future development could occur on this land. The City of Muskegon might also consider zoning this land as Open Space Conservation to preserve the natural communities on this land.

Actions

- 1) Work with the City of Muskegon to consider stronger protection of 50 acres designated as open space recreation, including the former AMOCO Tank Farm Site, and land on the East side of Ruddiman lagoon.
- 2) Propose and enact conservation zoning for 7 acres of shoreline between the former AMOCO Tank Farm Site, and Lakeshore Yacht Club.



Potential Conservation Areas

Legend

- Project Area
- Public Properties in Need of Greater Conservation

Land Use

- Other
- City of Muskegon
- Commercial/Indus
- Residential



0 500 1,000 2,000 3,000 4,000 Feet

Ecological Restoration Master Plan

Goal D) Permanently protect and conserve existing and restored habitats.

Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.

Action D1:1) Work with the City of Muskegon to consider stronger protection of 50 acres designated as open space recreation, including the former AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.

Procedure

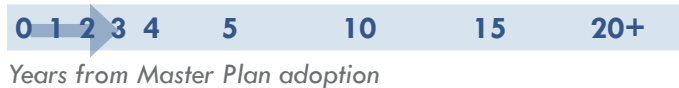
- A) Engage city planning departments and the general public to explore and enact protection.

Implementation details

Reference conditions: N/A

Affected area/size: The former AMOCO Tank Farm Site and east side of Ruddiman lagoon (50 acres).

Implementation Timeline: 0 to 3 years



Range of estimated costs: \$20,000 - \$120,000

Permitting requirements: None

Pre-implementation needs: Public notifications and administrative procedures.



Above, land on the east side of Ruddiman lagoon in need of more restrictive zoning; left, bike path winding through former AMOCO property

Goal D) Permanently protect and conserve existing and restored habitats.
Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.

Action D1:2) Propose and enact conservation zoning for 7 acres of shoreline between the former AMOCO Tank Farm Site, and Lakeshore Yacht Club.



7 acres of shoreline between the former AMOCO Tank Farm Site and Lakeshore Yacht Club

Procedure

- A) Engage city planning departments and the general public to explore and enact protection.

Implementation details

Reference conditions: N/A

Affected area/size: 7 acres

Implementation Timeline: 0 to 3 years

Range of estimated costs: \$5,000 - \$15,000

Permitting requirements: None

Pre-implementation needs: Public notifications and administrative procedures.



Years from Master Plan adoption

Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.

Restoration Trajectory: Provide permanent easements along privately-owned open spaces in the project area.

Overview

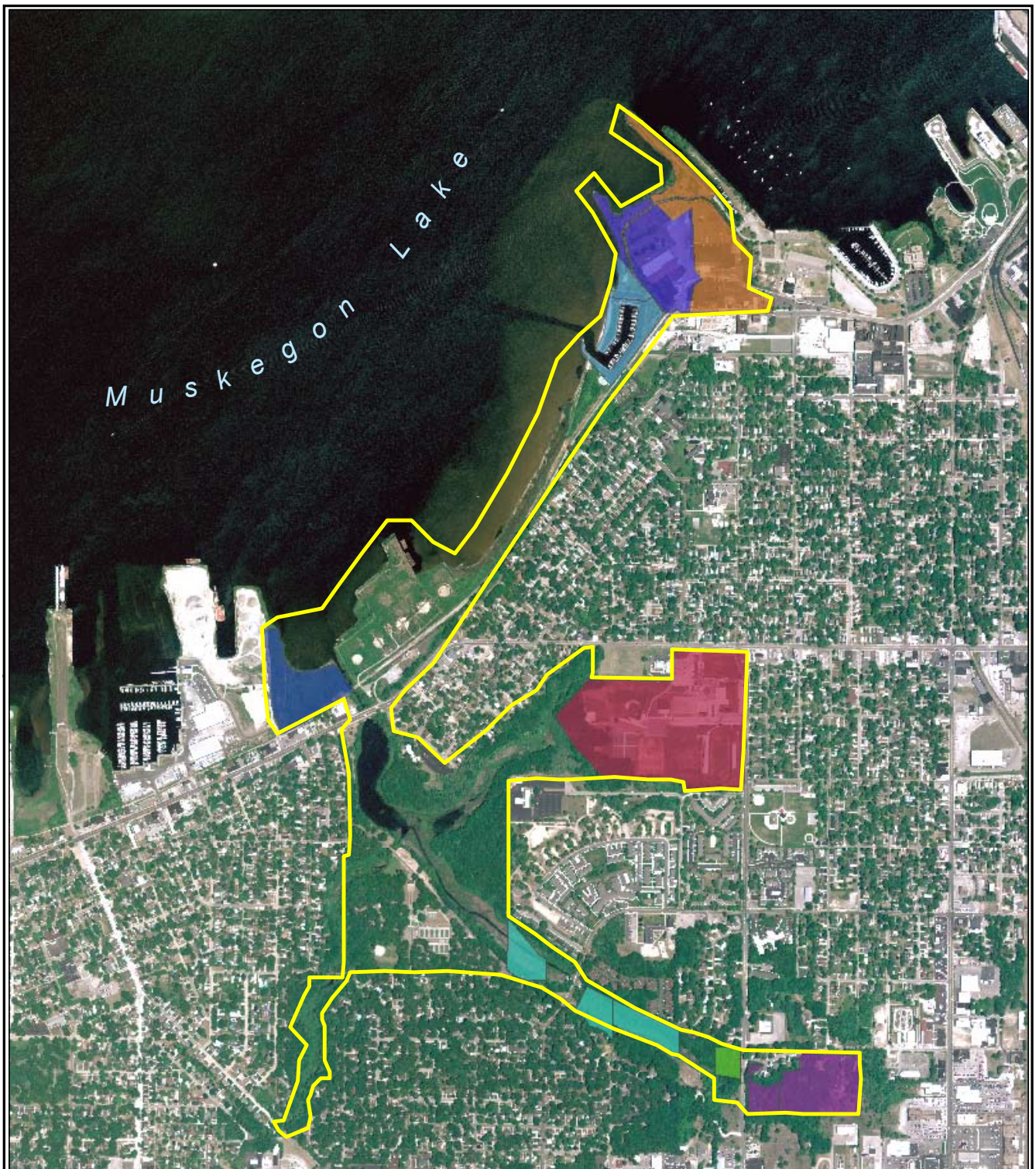
Approximately 34 acres of ecologically-valuable floodplain and forest along Ruddiman Creek both upstream and downstream of Barclay Street are either owned by private residents, and/or commercial and industrial ventures. These areas provide a wide buffer for Ruddiman Creek, and a corridor for the migration of animals through the open woodland, wetland. Their protection will ensure the continued viability of these habitats, and protection from future development or development-related infrastructure.

Potentially viable natural areas on privately-owned lands along the Muskegon Lake shoreline include approximately 7 acres on the west side of the Ruddiman Creek mouth, and approximately 10 acres extending from the lakeshore Yacht Club to the eastern land spit associated with Michigan Steel. Discussions with current landowners must be initiated and continue through the life of the master plan to maintain relationships and foster open communication regarding site development plans and potential conservation opportunities. Discussions should focus on conservation measures that could enhance property value and promote sustainable activities on the properties.

Land conservation strategies such as direct acquisition, conservation easement, and land transfers, can be used to facilitate the proposed restoration actions and ultimately place these parcels into permanent protection, without threat of careless development. The Land Conservancy of West Michigan may be able to help facilitate the conservation and protection of these private lands.

Actions

- 1) Initiate discussions with private landowners to determine the types of conservation measures that could increase property value and enhance future development plans.
- 2) Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.



Privately Held Properties in Project Area

Legend

Project Area

Private Properties

Achterhoff John Estate

Barclay Co LLC

GMCS Building Authority

Crow Investments LLC

Exit Your Way LLC

Lakeshore Yacht Club/Coles Quality Foods

Kirksey Investment Corp

Lacota LLC

0 500 1,000 2,000 3,000 4,000 Feet



Ecological Restoration Master Plan

Goal D) Permanently protect and conserve existing and restored habitats.

Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.

Action D2:1) Initiate discussions with private landowners to determine the types of conservation measures that could increase property value and enhance future development plans.

Procedure

- A)** Begin and maintain a dialogue with existing landowners to foster open communication regarding future site development plans.
- B)** Educate landowners of sustainable site activities that can improve ecological value and enhance future site development plans.

Implementation details

Reference conditions: Existing sustainable and regenerative developments.

Affected area/size: West side of the Ruddiman Creek mouth, and parcels on the Muskegon Lake shoreline. Approximately 51 acres.

Implementation Timeline: 0 to 10 years and ongoing



Years from Master Plan adoption

Range of estimated costs: \$2,000 - \$5,000 annually

Permitting requirements: None

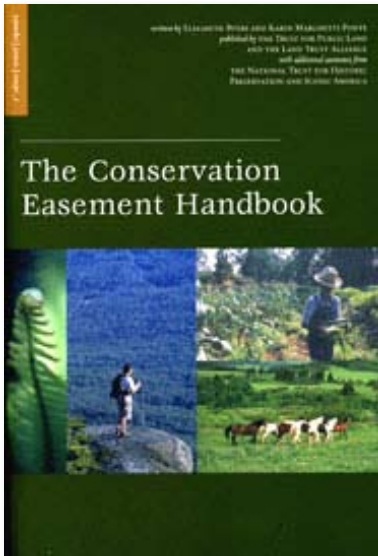
Pre-implementation needs: None



Above, stakeholder input

Goal D) Permanently protect and conserve existing and restored habitats.
Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.

Action D2:2) Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.



A resource for conservation easements

Procedure

- A) Work with the Land Conservancy of West Michigan to educate landowners and facilitate land protection.
- B) Purchase lands where possible.

Implementation details

Reference conditions: N/A

Affected area/size: Ruddiman Creek near Barclay Street, and parcels on the Muskegon Lake shoreline. Approximately 51 acres

Implementation Timeline: 0 to 10 years and ongoing



Range of estimated costs: \$25,000 - \$70,000 / acre

Permitting requirements: None

Pre-implementation needs: Assessment of property values and discussions with landowners.

Goal E)

Increase opportunities for recreation, education, and stewardship.

Overview

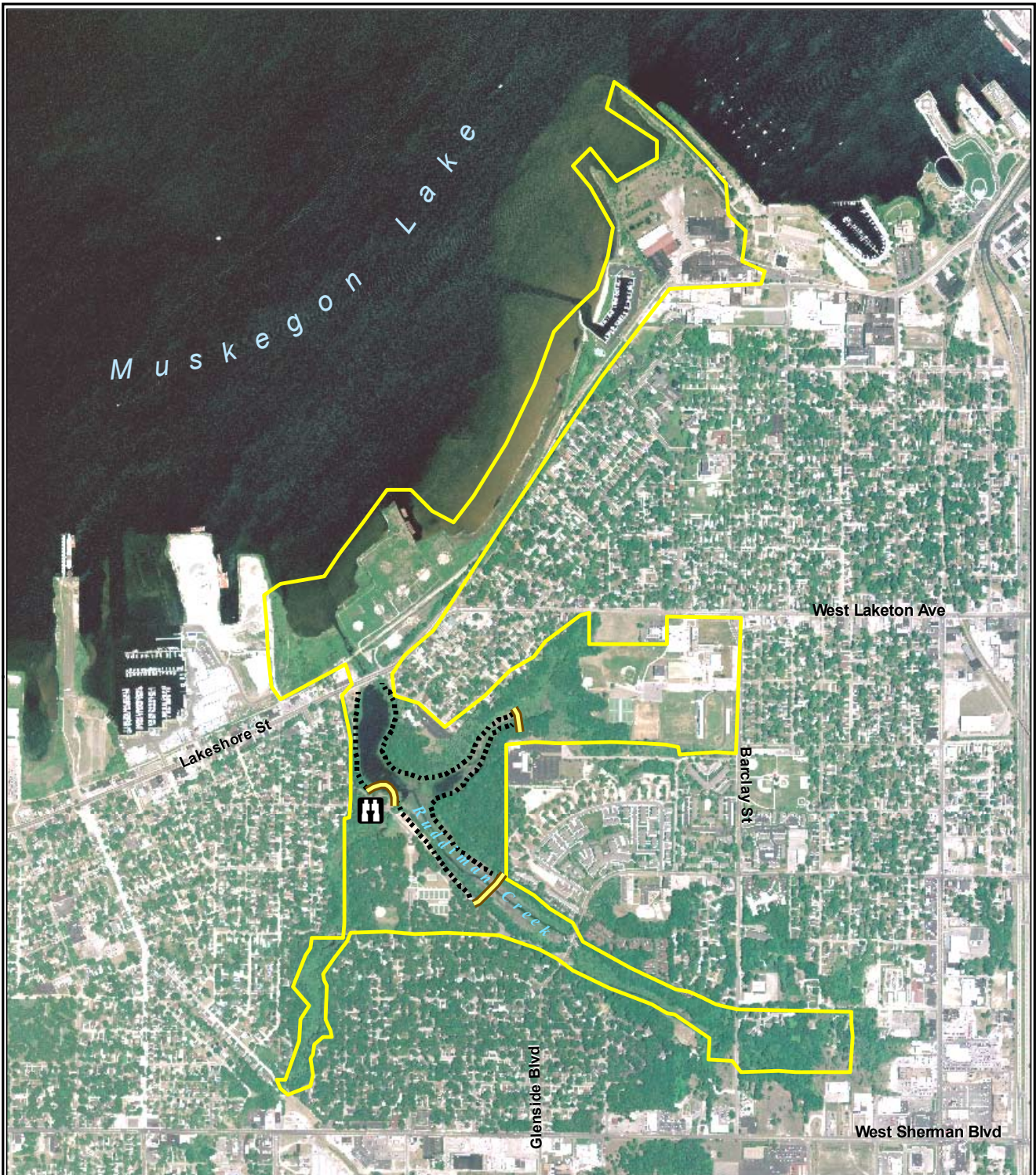
Ruddiman Creek and Nearby Shoreline have a history of human use for biking, walking, bird watching, fishing and canoeing/kayaking. Supporting and these activities is a critical element of a successful ecological restoration, as these actions encourage residents to gain knowledge of how their everyday actions affect water quality, human health, and the ecological processes of the landscape in which they live, develop a sense of caring for that environment, prioritize environmental health, and voluntarily modify their behaviors and practices toward more ecologically sustainable options. Long-term ecological sustainability is directly linked to the actions and attitudes of the people that live, work, and play in the landscape. The concept of environmental stewardship is that residents understand the value, care for, and interact meaningfully with their environmental resources, and thus are motivated to make decisions that improve the health of Ruddiman Creek and Nearby Shoreline.

Supporting the existing uses of Ruddiman Creek and Nearby Shoreline and fostering new interaction with the area that encourages education, stewardship and sustainable decisions requires several elements. City of Muskegon citizens are already visiting the area and an established interest in this place as a site for recreation and relaxation exists. The next step is to expand awareness of the area, provide passive and active educational opportunities, expand options for engagement with the area, and plan for the site so that it can meet the vision of its residents.

An effective public education and stewardship program includes both informative and interactive techniques of teaching. To be most successful, these educational experiences should be supplemented by opportunities for interaction with the natural environments that the Ecological Restoration Master Plan endeavors to protect and restore. To ensure widespread application and complete information throughout the watershed, the effort needs a coordinated approach in which the programs and activities of different providers are integrated. Ultimately, these educational and stewardship efforts aim to both harness the existing knowledge of local stakeholder and also increase their “capacity” to effectively advocate for the restoration of the area. By implementing the full suite of recommendations in this Master Plan, the future of the Muskegon lake and Ruddiman Creek can be one that is ecologically, culturally, and economically beneficial.

Objectives

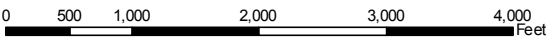
- E1)** Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing.
- E2)** Encourage opportunities for active recreation along, and in Ruddiman Creek and the Nearby Shoreline of Muskegon Lake.
- E3)** Promote local stewardship and education opportunities.



Potential Recreation Amenities

Legend

- Project Area
- Observation Platform
- Trail
- Boardwalk



Objective E1) **Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing**

Restoration Trajectory: Increase number and quality of passive recreation opportunities along the Ruddiman Creek and Nearby Shoreline area that inspire stewardship.

Overview

During the initial stakeholder meetings, the importance of viewing wildlife and habitat in the area was clear: People enjoy the area to look at the water, watch the birds that migrate through and simply appreciate the beauty of the area. Now that the area has been remediated, ensuring that the Ecological Restoration Master Plan provides continued opportunity for passive recreation is critical.

The existing bike trail serves as a key pathway along which passive recreation opportunities can be expanded via observation decks, benches and interpretative signage. While the lagoon is currently not part of the bike trail, creating opportunities for viewing the wildlife off the trail can encourage visitors to interact with a larger portion of the Ruddiman Creek and Nearby Shoreline project area in a sustainable manner. Providing a combination of methods to enable passive recreational activities throughout the area will encourage connection between the restored areas, appreciation for the location, and access for a variety of human and wildlife populations.

Actions

- 1) Explore the feasibility of placing an observation platform within the lagoon.
- 2) Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.

Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E1) Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing

Action E1:1) Explore the feasibility of placing an observation platform within the lagoon.



Passive recreation and observation opportunities

Procedure

- A) Work with local stakeholders and Fish & Wildlife Service members to identify best location for a platform that will allow for minimally invasive and disruptive viewing.
- B) Work with City of Muskegon officials to determine necessary permits and permissions.

Implementation details

Reference conditions: N/A

Affected area/size: Ruddiman Lagoon

Implementation Timeline: 0 to 3 years

0 1 2 3 4 5 10 15 20+

Years from Master Plan adoption

Range of estimated costs: \$4,000 - \$8,000

Permitting requirements: Local, state and federal permits may be required for work in and around waterways.

Pre-implementation needs: None

Objective E2) **Encourage opportunities for active recreation along and in Ruddiman Creek and the Nearby Shoreline of Muskegon Lake.**

***Restoration Trajectory:** Work with local stakeholders to increase the variety and quality of active recreation opportunities such as biking, canoeing, kayaking, hiking and general play along and in Muskegon lakeshore.*

Overview

People appreciate this area not only for the passive and reflective opportunities it provides, but also but for the chance to get outdoors and actively engage in their environment. The more opportunities for recreational activities that are sustainable, responsible and promote stewardship, the more people who will come to Ruddiman Creek and Nearby Muskegon Lake Shoreline, appreciate what it has to offer, and have a vested interest in maintaining its vitality.

The existing bike and pedestrian greenway link is both a solid example of one of the many ways people enjoy the area and a launching point from which to explore other options for recreation. Additional hiking/walking trails and wildlife observation areas could be established within the public property of Ruddiman lagoon and the Ruddiman corridor.

Actions

- A)** Explore the feasibility of placing a boardwalk in the lagoon area.
- B)** Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.



Opportunities for active recreation like fishing can be encouraged in certain areas.

Ecological Restoration Master Plan

Goal E) Increase opportunities for recreation, education, and stewardship.

Objective E2) Encourage opportunities for active recreation along and in Ruddiman Creek and the Nearby Shoreline of Muskegon Lake.

Action E2:1) Explore the feasibility of placing a boardwalk in the lagoon area.

Procedure

- A) Engage local stakeholders and Fish and Wildlife Service to consider appropriate location, width and sustainable materials.
- B) Evaluate how construction can avoid compromising habitat or wildlife movement.

Implementation details

Reference conditions: N/A

Affected area/size: Ruddiman Creek Lagoon and potentially along Ruddiman Creek

Implementation Timeline: 3 to 5 years



Years from Master Plan adoption

Range of estimated costs: \$50,000 - \$200,000

Permitting requirements: Local, state and federal permits may be required for work in and around waterways.

Pre-implementation needs: None



Boardwalk example

- Goal E)** Increase opportunities for recreation, education, and stewardship.
- Objective E2)** Encourage opportunities for active recreation along and in Ruddiman Creek and the Nearby Shoreline of Muskegon Lake.

Action E2:2)

Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.



Existing path on Ruddiman
west Branch

Procedure

- A)** Coordinate with stakeholders, USFWS and Michigan DNR to establish location and size of trails that are minimally invasive and disruptive.
- B)** Educate maintenance workers about proper trail and boardwalk maintenance.

Implementation details

Reference conditions: N/A

Affected area/size: 1 to 2 miles

Implementation Timeline: 3 to 5 years



Range of estimated costs: \$200,000 - \$1,200,000

Permitting requirements: Construction permits required.

Pre-implementation needs: None

Ecological Restoration Master Plan

Goal E) Increase opportunities for recreation, education, and stewardship.

Objective E3) Promote local stewardship and education opportunities.



***Restoration Trajectory:** Throughout the duration of the ecological restoration and beyond, create a tradition of student and public involvement with and education about the Ruddiman Creek and Nearby Shoreline areas.*

Overview

The drive to remediate and restore this area flows from many different sources. One of them is the desire to have a natural area in which children can play and from which students can learn. Much enthusiasm for a place can arise from casual interaction with it. A deeper sense of understanding, interest in stewardship and curiosity about ecological processes comes from classroom and life experiences that integrate learning, problem solving, and service activities with students' natural surroundings. Incorporating local knowledge of the area into classroom science and service curricula can be a meaningful way to learn about the shaping and preservation of landscapes.



Examples of community stewardship and education opportunities

Actions

- 1) Elicit support from adjacent schools to have students implement and monitor restoration measures.
- 2) Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.
- 3) Maintain and promote research opportunities through GVSU.
- 4) Hold seasonally relevant seminars on the ecology, history, environmental stewardship, or function of the area.
- 5) Encourage construction of informational signage describing local history vegetation and wildlife.

Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E3) Promote local stewardship and education opportunities.

Action E3:1) Elicit support from adjacent schools to have students implement and monitor restoration measures.

The White Pine Partnership (Muskegon Area Intermediate School District, Muskegon Conservation District, the Muskegon Chamber of Commerce, and the Odawa Native Americans, Little River Band) has developed education and stewardship programs that incorporate native teachings, local history, including the movement of humans along the landscape, and their impacts and cultural interactions. They have also developed curricula for educating about local natural resources and their influence on the economy. Once restored, the Ruddiman corridor and Muskegon lakeshore bike path make excellent backdrops for programs developed by the White Pine Partnership that teach these principles and help the students develop relationships with their community and the natural world.

The Greater Muskegon Catholic Schools have also expressed interest in education and stewardship activities. Muskegon Catholic Central High School and the surrounding property cover 44 acres on the northeast side of the watershed. The teachers currently use the property for environmental education, and teachers and administrators have discussed the possibility constructing a science, math and education facility near the stream. Such a facility would provide a “hands on” experience for exploration of renewable energies, impact on the environment and green principles. It would be available to all for study, and for education and meeting purposes. Greater Muskegon Catholic Schools’ prominent location in the watershed makes them ideal leaders in developing education and outreach programs based in science education and watershed stewardship. The schools’ teachers and administrators can play an important role in demonstrating and guiding the local community toward upland activities have a direct positive impact on the condition of Ruddiman Creek, the lagoon, the water quality of Muskegon Lake, and the quality of life in Muskegon.

Local businesses can also fund education programs through internships and scholarships based in community involvement and environmental awareness.

Procedure

- A) Identify coordinator to run student programs.
- B) Identify restoration opportunities and attributes that students could implement and monitor.
- C) Categorize opportunities into age-appropriate groupings.

Implementation details

Reference conditions: N/A

Affected area/size: the project area

Implementation Timeline: 1 to 10 years and ongoing



Range of estimated costs: \$20,000 - \$50,000/year
(number will increase depending on the scope and complexity of the activities)

Permitting requirements: None

Pre-implementation needs: None



Students assisting in stewardship activities

Ecological Restoration Master Plan

Goal E) Increase opportunities for recreation, education, and stewardship.

Objective E3) Promote local stewardship and education opportunities.

Action E3:2) Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.

There are groups poised to monitor the restoration of Ruddiman Creek and the Muskegon Lake shoreline. Currently, avian and amphibian communities are being monitored using methodologies created by Bird Studies Canada's, Great Lakes Volunteer Marsh Monitoring Program. Scientists at Grand Valley State University (GVSU) are monitoring fish and macroinvertebrate communities in the project area and an Environmental Biology Course aimed at monitoring restoration projects has been launched at Muskegon Community College. The Great Lakes Coastal Wetlands Consortium can also provide support for these monitoring efforts, including funding, research leadership, and database management to track restoration efforts and guide maintenance activities.



Stream monitoring



Procedure

- A) Make use of any and all contacts with fellow environmental groups, local experts and volunteers.
- B) Coordinate activities with the Great Lakes Coastal Wetlands Consortium and local monitoring programs affiliated with the Muskegon Lake Watershed Partnership.
- C) Identify leaders and select features to be collaboratively monitored.

Implementation details

Reference conditions: N/A

Affected area/size: the project area

Implementation Timeline: 0 to 10 years and ongoing



Range of estimated costs: \$10,000 - \$80,000 annually

Permitting requirements: Scientific collections permits

Pre-implementation needs: Identify leadership for a monitoring program.



Goal E) Increase opportunities for recreation, education, and stewardship.
Objective E3) Promote local stewardship and education opportunities.

Action E3:3) Maintain and promote research opportunities through GVSU.



The Grand Valley State University,
Annis Water Resources Institute

University students are a particularly important group to involve in local restoration efforts. They are at the age to better understand a range of influences on current conditions of an area. Furthering the influential role a hands-on project can play in developing their academic and career interests is one benefit of connecting students with restoration efforts. There is a great need for individuals trained in the prevention, remediation, restoration, and monitoring of contaminated sites.

Procedure

- A) Continue partnerships with GVSU departments and faculty.
- B) Coordinate efforts between faculty, student and restoration stewards to develop and maintain projects that can facilitate restoration measures (e.g. hydrologic studies and vegetative assessments).

Implementation details

Reference conditions: N/A

Affected area/size: the project area

Implementation Timeline: 0 to 10 years and ongoing



Range of estimated costs: \$5,000 - \$10,000 annually

Permitting requirements: None

Pre-implementation needs: None

Ecological Restoration Master Plan

Goal E) Increase opportunities for recreation, education, and stewardship.

Objective E3) Promote local stewardship and education opportunities.

Action E3:4) Hold seasonally relevant seminars on the ecology, history, environmental stewardship, or function of the area.

Procedure

- A) Contact existing nature centers and State Parks in the area to discuss existing programs and ideas, partnering if appropriate.
- B) Identify coordinator to design and lead seminars/hikes.
- C) Identify sponsors and create a program calendar.

Implementation details

Reference conditions: N/A

Affected area/size: Muskegon County and outside areas.

Implementation Timeline: 1 to 10 years and ongoing



Range of estimated costs: \$2,500 - \$10,000

Permitting requirements: None

Pre-implementation needs: None



Workshop seminar

- Goal E)** Increase opportunities for recreation, education, and stewardship.
- Objective E3)** Promote local stewardship and education opportunities.

Action E3:5) Encourage construction of informational signage describing local history vegetation and wildlife.



Educational signage

Procedure

- A) Designate potential locations for signs
- B) Determine number of signs desired
- C) Draft verbiage and graphics for signs
- D) Create signs out of sustainable material and secure in minimally invasive manner

Implementation details

Reference conditions: N/A

Affected area/size: Locations along Bike Trail and Ruddiman Creek

Implementation Timeline: 0 to 3 years



Range of estimated costs: \$5,000 - \$20,000

Permitting requirements: None

Pre-implementation needs: None

3.2 Alleviating Threats to Ecological Integrity

Currently, the project area exists in an extremely altered ecological condition compared to what occurred in pre-industrial times. Despite these changes and influences, diverse natural communities exist, while still others can be established in the current landscape matrix. Maintaining the stability and viability of the natural communities in the project area will depend on managing ongoing threats to ecological sustainability.

The goals, objectives and actions previously described in this plan have been created to address the BUIs, as well as to minimize future threats to ecological integrity and ecosystem viability.

Potential ecological threats in the project area identified in section 5.8 include:

- Impacts from urban hydrology (high discharge, erosion, and pollutants)
- Fluctuating lake levels and wave action
- Invasive vegetation and wildlife
- Impacts from recreational use
- Poorly planned development
- Global climate change

The table below demonstrates how threats will be minimized by following the actions presented in this master plan.

Threats to Ecological Integrity

Stressor	Potential Ecosystem Impact	Proposed Objectives for Mitigating Threats
Impacts from urban hydrology	Higher flood levels, discharges and velocities. Increased pollution and decreased water quality Stress to aquatic organisms	A1) Reduce flashy flows within Ruddiman Creek. A2) Improve water quality within Ruddiman Creek
Fluctuating lake levels and wave action	Habitat alteration from reduced access to water Displacement of wetland communities Wind and boat induced waves	B1) Enhance physical aquatic habitat features in the project area. B2) Protect and enhance native aquatic vegetation along the Muskegon Lake shoreline. B4) Restore and enhance existing wetlands throughout the project area.
Invasive vegetation and wildlife	Loss of habitat variability/diversity Displacement of native species Direct destruction and consumption of native species Altering natural processes (hydrology nutrients)	B1) Enhance physical aquatic habitat features in the project area. B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area. B4) Restore and enhance existing wetlands throughout the project area. B5) Reduce the abundance of invasive plant species in the project area. E3) Promote opportunities for stewardship and education.
Impacts from recreational use	Litter and debris Light and noise pollution Pet predation / disturbance Erosion from trail usage	D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat. D2) Encourage major private landowners to establish permanent easements. E3) Promote opportunities for stewardship and education.
Poorly Planned Development	Direct displacement of natural communities. Alteration of watershed hydrology. Degradation of stream channel conditions. Increase in potential pollution sources.	A1) Reduce flashy flows within Ruddiman Creek. A2) Improve water quality within Ruddiman Creek D1) Place publicly held properties into permanent easements that protect and conserve restored and existing wildlife habitat. D2) Encourage major private landowners to establish permanent easements that protect and conserve restored and existing wildlife habitat.
Global climate change	Increased air temperatures Decreased precipitation Decreased lake levels Alteration of vegetation community composition and distribution Stress to aquatic organisms	The impact of all the restoration objectives and actions in the Plan serve to improve water quality, increase habitat complexity, and species diversity. Such a community may be better able to contend with climate change.

Goals, objectives and actions, and associated BUIs

Goal	Objective	Action	BUI		
			Loss of fish and wildlife habitat	Degradation of fish and wildlife populations	Degradation of benthos
Goal A: Improve hydrology and water quality in Ruddiman Creek.	Objective A1) Reduce flashy flows within Ruddiman Creek.	Action A1.1 - Review existing hydrologic analysis and determine data gaps and needs for additional research.	✓		
		Action A1.2 - Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.	✓		
		Action A1.3 - Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1.2 above.	✓		✓
		Action A1.4 - Educate landowners about stormwater BMPs to reduce overland flow of stormwater.	✓		✓
		Action A2.1 - Continually monitor, identify and eliminate illicit discharges.	✓		
	Objective A2) Improve water quality of Ruddiman Creek.	Action A2.2 - Install BMPs that facilitate water quality treatment and where feasible, infiltration.	✓		✓
		Action A2.3 - Educate homeowners about water quality BMPs.	✓		✓
		Action B1.1 - Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.	✓	✓	✓
		Action B1.2 - Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.	✓	✓	✓
		Action B1.3 - Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.	✓	✓	✓
Goal B: Restore fish and wildlife habitat within the project area.	Objective B1) Enhance physical aquatic habitat features in the project area.	Action B1.4 - Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.	✓	✓	
		Action B2.1 - Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.	✓		✓
		Action B3.1 - Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Blvd.	✓	✓	
		Action B3.2 - Expand the riparian and upland buffers along the Muskegon Lake shoreline, and along the bike path.	✓	✓	
		Action B3.3 - Reconfigure the Glenside Avenue culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.	✓	✓	
	Objective B4) Restore and enhance existing wetlands throughout the project area.	Action B4.1 - Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.	✓	✓	✓
		Action B4.2 - Explore opportunities for wetland creation at the former AMOCO tank farm site.	✓	✓	
		Action B4.3 - Encourage private landowners to establish native wetland vegetation where it is compatible with future development plan and where proper hydrology and soils exist.	✓	✓	
		Action B5.1 - Conduct invasive species management in the project area.	✓		
		Action B5.2 - Provide information to homeowners about invasive species management and the use of native plants in the landscape.	✓		
Goal C: Restore fish and wildlife populations in the project area.	Objective C1) Track the abundance and diversity of native avian, fish, herpetofauna, and macroinvertebrate species in the project area.	Action C1.1 - Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities in the project area.	✓	✓	✓
		Action D1.1 - Work with the City of Muskegon to consider stronger protection of 50 acres designated as open space recreation, including the former AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.	✓		
		Action D1.2 - Propose and enact conservation zoning for 7 acres of shoreline between the former AMOCO Tank Farm Site, and Lakeshore Yacht Club.	✓		
		Action D2.1 - Initiate discussions with private land owners to determine the types of conservation measures that could increase property value and enhance future development plans.	✓		
		Action D2.2 - Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.	✓		
	Objective E1) Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing.	Action E1.1 - Explore the feasibility of placing an observation platform within the lagoon.			
		Action E2.1 - Explore the feasibility of placing a boardwalk in the lagoon area.			
		Action E2.2 - Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.			
		Action E3.1 - Elicit support from adjacent schools to have students implement and monitor restoration measures.	✓		
		Action E3.2 - Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.		✓	✓
Goal D: Permanently protect and conserve existing and restored habitats.	Objective E3) Promote local stewardship and education opportunities.	Action E3.3 - Maintain and promote research opportunities through GVSU.	✓	✓	✓
		Action E3.4 - Hold seasonally relevant seminars on the ecology, history, environmental stewardship and function of the area.			
		Action E3.5 - Encourage construction of informational signage describing local history vegetation and wildlife.			
Goal E: Increase opportunities for recreation, education, and stewardship.					



3.3 Addressing the Beneficial Use Impairments

There are nine recognized BUIs for the Muskegon AOC. This Ecological Restoration Master Plan directly addresses three habitat-related BUIs, including “loss of fish and wildlife habitat”, “degradation of fish and wildlife populations”, and “degradation of benthos” in the Ruddiman Creek and Muskegon Lakeshore project area.

The table below demonstrates the linkages between ecological restoration activities recommended within Ruddiman Creek, along the shoreline of Muskegon Lake, and the BUIs they address. Quantitative delisting criteria for the habitat-related BUIs are currently being developed.

3.4 Ecological Benchmarks and the Adaptive Management Framework

Because natural communities undergo a process of maturation, succession, and diversification over time, it will take some years between initial ecosystem

restoration efforts and the final development of resilient, diverse ecosystems that contain the full suite of attributes expressed in the “guiding principles”. Continual post-project monitoring by qualified restoration ecologists will allow the measurement, documentation and ranking of this progression over time. Each habitat type will have different restoration trajectories, defined by their reference ecosystems and standard indices, and so the benchmarks for this progression will be distinct for each community. The “success” of restoration actions can be determined through the evaluation of post-project monitoring data, and the use of ecological reference information to determine if ecosystem succession is occurring along the desired trajectory. Feedback from monitoring efforts will inform decisions on adjusting restoration actions and even the trajectories depending on the response of the system. Monitoring data can also be used to modify the timing of restoration actions, using adaptive management as necessary to maintain a logical sequence of restoration activities (e.g. invasive species must be treated before native plants are established).

The restoration of a particular ecosystem component is completed when it has been determined that the desired restoration trajectory has been fulfilled, including:

- The quantity or extent of the desired ecosystem element has been established.
- The restored ecosystem has similar species assemblage and distribution as the reference ecosystem.
- The “guiding principles” of ecosystem restoration are achieved.

The Master Plan is structured such that when all restoration Actions under a particular Objective are fulfilled, then that Objective is completed. Similarly, when all Objectives of a Goal are achieved, then that Goal is realized. Finally, when all Goals are achieved, then the Vision of a restored Ruddiman Creek and Muskegon Lake Shoreline will become a reality. Following this plan will result in addressing the target BUIs in the project area. This may occur before all of

the objectives of each goal have been completed.

If, according to post-project monitoring data, a restoration action is not succeeding, additional studies or surveys will need to be performed to evaluate the source(s) of ecological stress, and the strategy adjusted accordingly. This Master Plan is intended to be dynamic and flexible, a “living document” that can be adjusted to account for new information and changing environmental conditions.

3.5 Monitoring and Maintenance

A restoration monitoring program will enable the successes and lessons learned in this Plan to be tabulated and communicated to Master Plan managers. The Managers will then use the information to direct maintenance and resource management activities to maintain the trajectory of each restoration Objective in the Plan. The information can also be used to guide the development of future restoration projects with similar objectives. The restoration monitoring and maintenance program should begin with existing conditions and document initial post-restoration conditions and continue for the life of the project. Funding for a monitoring and maintenance plan is a requirement for the success of each restoration project. This should include money set aside for training and education for the employees maintaining and managing natural habitats, and adequate funds for continued monitoring and reporting. A sound monitoring and maintenance plan will provide cost effective measures for monitoring and maintenance of all restoration activities.

Monitoring will be incorporated into every restoration Action that is implemented, potentially including quantitative indices of vegetation, benthic macroinvertebrate, fish, amphibian and avian communities, qualitative measures of stream and wetland habitat, and monitoring for threats, such as invasive species, and chemical water quality. This information will be reported to the Master Plan managers as the Plan is implemented. This way the



timing of Actions can be modified using adaptive management as necessary to maintain a logical sequence of restoration activities (e.g. invasive species must be treated before native plants are established).

Active monitoring specified in the Plan should be coordinated by the managers of the Plan and may be conducted by volunteers, university scientists, state agencies, and or private consultants, depending on funding and the need for technical expertise. The Great Lakes Coastal Wetlands Consortium can also provide support for these monitoring efforts, including funding, research leadership, and database management to track restoration efforts and guide maintenance activities. All monitoring must be coordinated to ensure that:

- monitoring efforts are not duplicated,
- the data are useful for the ultimate determination of BUI status, and
- the data can be efficiently summarized and communicated to the Master Plan managers.

Once the monitoring plan is implemented, it will provide the link between the active monitoring and the managers of the Master Plan. This will ensure adaptive management is incorporated into ecosystem restoration in the project area.

3.6 Phasing of Restoration Actions

The restoration of Muskegon Lake, Ruddiman Creek, and the nearby Shoreline will occur incrementally. To provide an organized framework for implementation, it is recommended that work occur in four distinct phases. Phasing will enable the stakeholders to recognize the completion of key milestones in the restoration process. It also allows for flexibility where stakeholder needs change, or where unforeseen obstacles require adaptive management and phasing adjustments.

PHASE 1 0-2 years from Master Plan adoption:

- Hydrologic, hydraulic and GIS/field studies of the Ruddiman Creek watershed (A1:1, A1:2);
- Ongoing monitoring for illicit discharges.

(A2:1);

- Remove debris and reconstruct the outlet of Ruddiman Creek (B1:2);
- Select areas and provide large woody debris habitat in and along Ruddiman Creek and lagoon (B1:3);
- Initiate the restoration and expansion of riparian buffers along Ruddiman Creek and the bike path (B3:1, B3:2);
- Begin invasive species surveys and invasive species management plan (B5:1);
- Initiate dialogue with the City of Muskegon, and private/commercial landowners regarding land conservation and wetland enhancement (B4:3, Goal D).
- Explore the feasibility for physical amenities such as wildlife blinds, informational kiosks, boardwalks, and hiking trails (E1:1, E1:2, E2:1, E2:2);
- Continue and expand public outreach, environmental stewardship, monitoring and education programs (E3:1, E3:4, E4:1, E4:2);



PHASE 2 3-5 years from Master Plan adoption:

- Initiate stormwater management, in the Ruddiman Creek watershed (A1:3, A2:2);
- Ongoing monitoring for illicit discharges. (A2:1);
- Begin removing concrete debris along Muskegon Lake, including regrading, and revegetating the shoreline (B1:1, B2:1, B4:1);
- Initiate the feasibility of reconfiguring the Glenside Blvd culvert (B3:3, B1:4);
- Investigate the expedited remediation of the former AMOCO tank farm site and explore opportunities for wetland creation (B4:2);
- Continued coordination with the City of Muskegon, and private/commercial landowners regarding land conservation and wetland enhancement (B4:3, Goal D).
- Continue restoration and expansion of riparian buffers along Ruddiman Creek and the bike path (B3:1, B3:2);
- Begin invasive species management in key areas (B5:1);
- Install some physical amenities such as wildlife blinds, informational kiosks, boardwalks, and hiking trails (E1:1, E1:2, E2:1, E2:2);
- Continued public outreach and education, expand monitoring efforts for fish and wildlife communities (Goal C, E3:2, E3:3, E3:4, E4:1, E4:2);

PHASE 3 6-10 years from Master Plan adoption:

- Continue stormwater management projects, in the Ruddiman Creek watershed (A1:3, A2:2);
- Ongoing monitoring for illicit discharges. (A2:1);
- Continue removing concrete debris along Muskegon Lake, including regrading, and revegetating the shoreline (B1:1, B2:1, B4:1);
- Begin the reconstruction of the of the Glenside Blvd culvert (B3:3, B1:4);
- Remediation of the former AMOCO tank farm site prior to wetland creation (B4:2);

- Finalize coordination with the City of Muskegon, and regarding land conservation and wetland enhancement (D1:1, D1:2);
- Continue coordination with private/commercial landowners private/commercial landowners regarding land conservation and wetland enhancement (D2:1);
- Complete the restoration and expansion of riparian buffers along Ruddiman Creek and the bike path (B3:1, B3:2);
- Complete major invasive species management efforts and begin invasive species monitoring according to the invasive species management plan (B5:1);
- Complete installation of approved physical amenities (E1:1, E1:2, E2:1, E2:2);
- Expanded public outreach and education, expand monitoring efforts for fish and wildlife communities (Goal C, E3:1, E3:2, E3:3, E3:4, E4:1, E4:2);

PHASE 4 11 years through completion of ecosystem restoration efforts:

- Complete all major stormwater management projects, in the Ruddiman Creek watershed (A1:3, A2:2);
- Ongoing monitoring for illicit discharges. (A2:1);
- Complete removal of concrete debris along Muskegon Lake, including regrading, and revegetating the shoreline (B1:1, B2:1, B4:1);
- Complete reconstruction of the of the Glenside Boulevard culvert (B3:3, B1:4);
- Complete remediation of the former AMOCO tank farm site and wetland creation (B4:2);
- Continue coordination with private/commercial landowners private/commercial landowners regarding land conservation and wetland enhancement (D2:1);
- Conduct invasive species monitoring according to the invasive species management plan (B5:1);
- Expanded public outreach and education, expand monitoring efforts for fish and wildlife communities (Goal C, E3:1, E3:2, E3:3, E3:4, E4:1, E4:2);

Ecological Restoration Master Plan



Certain strategies must be performed prior to full scale restoration actions. Ecological threats should be assessed and mitigated prior to habitat restoration efforts, to ensure that the investment in ecological restoration is not compromised by ongoing or future disturbances. Priority land protection actions should be initiated prior to restoration, to assure that entities responsible for implementing the proposed actions have the legal jurisdiction to proceed. Finally, the collection of additional necessary baseline information, including invasive species surveys, reference condition surveys, and discharge data should be performed to inform restoration design.

These initial steps are critical efforts to the restoration design process, providing essential data and defining the extent of these projects. For example: it will be inadvisable to design the shoreline buffer proposed in Action B4:1 without reference survey information

obtained from Duck Lake, Pentwater Lake, or a similar system, and without negotiations with private landowners and the City of Muskegon about potential shoreline restoration.

Phase 2 includes the initiation of most ecological restoration efforts detailed in Goals A and D, and the continuation of ecosystem conservation and public outreach efforts in Goal B and Goal E.

The final phases are defined by the continuation and completion of ongoing restoration efforts. Active post-project monitoring should begin at the completion of the restoration efforts. This will facilitate the adaptive management process by determining if the trajectories of each restoration Objective are being met. Expanded environmental stewardship, education, and outreach programs are also a large part of the final phases of the Plan.

Phasing of Goals, Objectives, and Restoration Actions

MUSKEGON LAKE, RUDDIMAN CREEK AND NEARBY SHORELINE ECOLOGICAL RESTORATION MASTER PLAN			Years from Master Plan Adoption											
Goal	Objective	Action	0	1	2	3	4	5	6	7	8	9	10	11+
Goal A: Improve hydrology and water quality in Ruddiman Creek.	Objective A1) Reduce flashy flows within Ruddiman Creek.	Action A1:1 - Review existing hydrologic analysis and determine data gaps and needs for additional research.												
		Action A1:2 - Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.												
		Action A1:3 - Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.												
		Action A1:4 -Educate landowners about stormwater BMPs to reduce overland flow of stormwater.												
	Objective A2) Improve water quality of Ruddiman Creek.	Action A2:1 -Continually monitor, identify and eliminate illicit discharges.												
		Action A2:2- Install BMPs that facilitate water quality treatment and where feasible, infiltration.												
		Action A2:3- Educate homeowners about water quality BMPs.												
Goal B: Restore fish and wildlife habitat in the project area.	Objective B1) Enhance physical aquatic habitat features in the project area.	Action B1:1 - Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.												
		Action B1:2- Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.												
		Action B1:3 - Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.												
		Action B1:4 - Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.												
	Objective B2) Protect and enhance native submerged aquatic vegetation along the Muskegon Lake shoreline.	Action B2:1 - Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.												
	Objective B3) Enhance terrestrial habitat including riparian buffers and corridors in the project area.	Action B3:1 - Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Blvd.												
		Action B3:2 - Expand the riparian and upland buffers along the Muskegon Lake shoreline, and along the bike path.												
		Action B3:3 - Reconfigure the Glenside Avenue culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.												
	Objective B4) Restore and enhance existing wetlands throughout the project area.	Action B4:1 - Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.												
		Action B4:2 - Explore opportunities for wetland creation at the AMOCO tank farm site.												
		Action B4:3 - Encourage private landowners to establish native wetland vegetation where it is compatible with future development plan and where proper hydrology and soils exist.												
	Objective B5) Reduce the abundance of invasive plant species in the project area.	Action B5:1 - Conduct invasive species management in the project area.												
		Action B5:2 - provide information to homeowners about invasive species management and the use of native plants in the landscape.												
Goal C: Restore fish and wildlife populations in the project area.	Objective C1) Track the abundance and diversity of native avian, fish, herpetofauna, and macroinvertebrate species in the project area.	Action C1:1 - Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities in the project area.												
Goal D: Permanently protect and conserve existing and restored habitats.	Objective D1) Place publicly held properties in permanent easements that protect and conserve restored and existing wildlife habitat.	Action D1:1 – Work with the City of Muskegon to consider stronger protection of 50 acres designated as lakefront recreation and open space recreation, including the AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.												
		Action D1:2 – Propose and enact conservation zoning for 7 acres of shoreline between the AMOCO Tank Farm Site, and Lakeshore Yacht Club.												
	Objective D2) Encourage major private landowners to establish permanent easements to protect restored and existing wildlife habitat.	Action D2:1 – Initiate discussions with private land owners to determine the types of conservation areas that could increase property value and enhance future development plans.												
		Action D2:2 – Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.												
Goal E: Increase opportunities for recreation, education, and stewardship.	Objective E1) Work with local stakeholders to encourage opportunities for passive recreation and wildlife viewing.	Action E1:1 - Explore the feasibility of placing an observation platform within the lagoon.												
	Objective E2) Encourage opportunities for active recreation along, and in Ruddiman Creek and the nearby shoreline of Muskegon Lake.	Action E2:1 - Explore the feasibility of placing a boardwalk in the lagoon area.												
		Action E2:2 - Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.												
	Objective E3) Promote local stewardship and education opportunities.	Action E3:1 - Continue working with adjacent schools for assistance with implementing restoration measures.												
		Action E3:1- Elicit support from adjacent schools to have students implement and monitor restoration measures.												
		Action E3:2 - Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.												
		Action E3:3 - Maintain and promote research opportunities through GVSU.												
		Action E3:4 - Hold seasonally relevant seminars on the ecology, history, environmental stewardship andr function of the area.												
		Action E3:5 - Encourage construction of informational signage describing local history, and different plants and wildlife that appear in the area throughout the year.												

Ecological Restoration Master Plan

Approximate Cost Range for each Restoration Action

MUSKEGON LAKE, RUDDIMAN CREEK AND NEARBY SHORELINE ECOLOGICAL RESTORATION MASTER PLAN			Cost Meter													
Action	Size	Cost	≤ \$1K	\$5K	\$10K	\$20K	\$50K	\$100K	\$150K	\$200K	\$300K	\$400K	\$500K	\$1M	\$2M	\$5M +
Action A1:1 - Review existing hydrologic analysis and determine data gaps and needs for additional research.	watershed-wide	\$25,000 to \$40,000														
Action A1:2 - Identify properties and areas in the watershed where stormwater BMPs would be practical and beneficial, including retrofits of existing outfalls, where feasible.	watershed-wide	\$20,000 - \$70,000														
Action A1:3 - Develop construction documents and construct BMPs for the most feasible priority sites identified in Action A1:2 above.	watershed-wide	\$700,000 to \$2,100,000														
Action A1:4 -Educate landowners about stormwater BMPs to reduce overland flow of stormwater.	watershed-wide	\$1,000 to \$2,000 (annually)														
Action A2:1 -Continually monitor, identify and eliminate illicit discharges.	watershed-wide	\$5,000 to \$10,000 (annually)														
Action A2:2- Install BMPs that facilitate water quality treatment and where feasible, infiltration.	watershed-wide	See Action A1:3 above.														
Action A2:3- Educate homeowners about water quality BMPs.	watershed-wide	\$500 tp \$,1000 (annually)														
Action B1:1 - Remove concrete debris, recontour and revegetate shoreline areas near the Ruddiman mouth and the former AMOCO tank farm.	Approx 4,000 LF	\$420,000 to \$1,200,000														
Action B1:2- Remove debris from the mouth of Ruddiman Creek and install a more natural grade control structure to promote fish passage.	2,500 square feet	\$10,000 to \$40,000														
Action B1:3 - Incorporate large woody debris in the banks, channel, and floodplain of Ruddiman Creek and the lagoon.	N/A	\$10,000 to \$20,000														
Action B1:4 - Reconfigure the Glenside Boulevard culvert for improved fish passage when it is near the end of its useful life.	4,000 square feet	\$200,000 to \$500,000														
Action B2:1 - Identify potential locations for enhancement of natural emergent shoreline vegetation and install and monitor test plots.	6 acres	\$60,000 to \$120,000														
Action B3:1 - Expand the Ruddiman Creek riparian buffer within McGraft Park between Lakeshore Drive and Glenside Blvd.	3 acres	\$15,000 to \$200,000														
Action B3:2 - Expand the riparian and upland buffers along the Muskegon Lake shoreline, and along the bike path.	6 acres	\$60,000 to \$220,000														
Action B3:3 - Reconfigure the Glenside Avenue culvert for improved wildlife passage when it is near the end of its useful life according to Objective B1, Action 4 above.	See Action B1:4 above.	See Action B1:4 above.														
Action B4:1 - Concurrent with all Goal B objectives re-establish Great Lakes Marsh habitats and restore existing shoreline wetlands along the shore of Muskegon Lake between Ruddiman Creek and the Lakeshore Yacht Club.	7 acres	\$70,000 to \$140,000														
Action B4:2 - Explore opportunities for wetland creation at the AMOCO tank farm site.	30 acres	\$2,000,000 to \$10,000.000														
Action B4:3 - Encourage private landowners to establish native wetland vegetation where it is compatible with future development plant and where proper hydrology and soils exist.	17	\$35,000 to \$70,000														
Action B5:1 - Conduct invasive species management in the project area.	15 acres	\$40,000 to \$75,000														
Action B5:2 - provide information to homeowners about invasive species management and the use of native plants in the landscape.	watershed-wide	\$500 to \$1,000														
Action C1:1 - Design monitoring programs to collect data on fish, herpetofauna, avian, and macroinvertebrate communities in the project area.	project area	Based on Goals A & B above.														
Action D1:1 – Work with the City of Muskegon to consider stronger protection of 50 acres designated as lakefront recreation and open space recreation, including the AMOCO Tank Farm Site, and land on the east side of Ruddiman lagoon.	50 acres	\$20,000 to 120,000														
Action D1:2 – Propose and enact conservation zoning for 7 acres of shoreline between the AMOCO Tank Farm Site, and Lakeshore Yacht Club.	7acres	\$5,000 to \$15,000														
Action D2:1 – Initiate discussions with private land owners to determine the types of conservation resources that could increase property value and enhance future development plans.	watershed-wide	\$2,000 to \$5,000 (annually)														
Action D2:2 – Engage in discussions with relevant land owners to determine willingness to sell or place designated lands into conservation easements.	51 acres	\$25,000 to \$70,000/acre														
Action E1:1 - Explore the feasibility of placing an observation platform within the lagoon.	minimal	\$2,000 to \$5,000														
Action E2:1 - Explore the feasibility of placing a boardwalk in the lagoon area.	60 to 200LF	\$500/LF														
Action E2:2 - Explore the feasibility of creating hiking and wildlife observation trails on public property in the Ruddiman corridor.	1 to 2 miles	\$120/LF														
Action E3:1- Elicit support from adjacent schools to have students implement and monitor restoration measures.	project area	\$20,000 to \$50,000/year														
Action E3:2 - Elicit support from existing groups and set up monitoring networks to implement and monitor restoration measures.	project area	\$10,000 to \$80,000/year														
Action E3:3 - Maintain and promote research opportunities through GVSU.	project area	\$5,000 to \$100,000														
Action E3:4 - Hold seasonally relevant seminars on the ecology, history, environmental stewardship andr function of the area.	N/A	\$2,500 to \$10,000														
Action E3:5 - Encourage construction of informational signage describing local history, and different plants and wildlife that appear in the area throughout the year.	project area	\$5,000 to \$20,000														

3.7 Funding the Ecological Restoration Management Actions

The Ruddiman Creek and Nearby Shoreline Ecological Restoration Master Plan assesses the ecological health of a small part of the Muskegon AOC and details actions to improve that health. The actions, some costly, will require federal, state, and local financial support to implement. The Muskegon Lake Watershed Partnership has stepped forward to adopt and begin implementation of several of those actions. The U.S. EPA Great Lakes National Program Office is committed to helping find funding. Conversations with the National Oceanic and Atmospheric Administration and U.S. Army Corps of Engineers regarding their grant programs look promising. In addition, the funding programs listed below, although not comprehensive, offer a range of grant opportunities for the community to explore.

- Grants from Federal Agencies: <http://www.grants.gov>
- Great Lakes Protection Fund: <http://www.glpf.org/>
- Great Lakes Watershed Restoration Grant

Program: http://www.nfwf.org/AM/Template.cfm?Section=Browse_All_Programs&CONTENTID=5337&TEMPLATE=/CM/ContentDisplay.cfm

- Lake Michigan Coastal Management Program: http://www.michigan.gov/deq/0,1607,7-135-3313_3677_3696-11188--,00.html
- National Oceanic and Atmospheric Administration (NOAA): http://www.nmfs.noaa.gov/habitat/restoration/funding_opportunities/funding_ner.html
- U.S. Army Corps of Engineers Habitat Initiative: <http://www.glhi.org/>
- U.S. EPA Great Lakes National Program Office (GLNPO) Funding Program: <http://www.epa.gov/glnpo/fund/glf.html>
- U.S. Fish and Wildlife Service: <http://www.fws.gov/grants/>

The costs associated with the proposed restoration strategies are provided in the fold out table.

Note that these are planning level cost estimates for design, engineering, construction, and maintenance. Actual costs may vary depending on the nature and degree of implementation and cost escalation over time.